MASSACHUSETTS
BAY
TRANSPORTATION
AUTHORITY

TECHNICAL SPECIFICATION

EE&QA - 770

Materials and Workmanship Specification

ISSUED: **September 23, 2008**

REVISIONS: **IR**

SUBWAY OPERATIONS DIRECTORATE
EQUIPMENT ENGINEERING AND QUALITY ASSURANCE

Materials and Workmanship

1.0 Materials & Workmanship

The vehicles contain a variety of miscellaneous components including: labels, grommets, springs, gaskets, mounting hardware, captive screws, threaded fasteners, washers, lock washers, nuts, hangers, tape, tamper proof hardware, elastomeric components, seals, couplings, link pins and hook plates, vertical support rods/eye bolts, packing seals, springs, cotter pins, fuses, etc. Wherever such components are identified to be replaced, they shall be replaced in kind with new components.

1.1 General Description

Workmanship and Quality shall conform to the best manufacturing practices in all respects. All work shall be performed by properly trained, qualified personnel skilled in the tasks they will be performing. All work shall be performed using correct tooling and procedures.

All new materials and components used in the rebuild of the vehicle shall comply with the requirements of this section.

Surfaces exposed to passengers, crew, or maintenance personnel shall be kept smooth and free of burrs, sharp edges or corners, and dangerous protrusions. The vehicle rebuild shall avoid pinch points, tripping hazards, snagging points, water traps, and debris accumulation points.

Carbody structural parts that are permanently covered and concealed after assembly shall not be made of copper, copper bearing aluminum alloys, brass, bronze, silver, or nickel.

Foreign matter, such as shavings, chips, etc., shall be completely removed from all parts of the vehicle, its components, assemblies and subassemblies, whether hidden or exposed.

Materials for the rebuild of the vehicle shall be in accordance with the stated specification or cited standard, unless The Contractor obtains Massachusetts Bay Transportation Authority's (MBTA), herein referred to as the Authority, approval for a substitution in writing. Alternate standards may be proposed, but must be supplied in English, with a narrative comparing both standards, and citing justification why the substitution is equivalent.

All materials shall perform safely and satisfactorily within their operating environment and in accordance with their intended function.

Whenever a commercial material is not covered by a specification or standard, The Contractor shall identify the material by the commercial trademark, name, and address of the supplier. The Contractor shall submit a description, and the technical data specifications, of the material composition for approval The Contractor shall maintain records that trace all materials to their manufacturers, and shall verify compliance with quality standards specified or cited in these Provisions.

[CDR 001]

Single-source materials shall not be permitted unless approved by the Authority. Approval shall be determined on a case-by-case basis. Specification equivalency and benefit data for any substitution to a cited standard shall be submitted to the Authority for review and approval.

[CDR 002]

Unless specifically authorized by the Authority, the following materials shall not be used in the rebuild of the vehicle:

- PVC
- Asbestos
- Lead in brake shoes
- Urethane foam
- Chlorinated fluorocarbons that may cause environmental problems or handling hazards
- Materials that, in their normal installed state, emit products that are known to be toxic or irritants
- Materials that, in their normal installed state, emit products that are known to be toxic or irritative
- Beryllium

The Contractor shall keep on file Material Safety Data Sheets (MSDS) for all chemical materials (paints, solvents, adhesives, caulking, etc) used in the rebuild of the vehicle, and provide MSDS information as requested by the Authority for any additional material in question. A copy of each MSDS shall be submitted to the Authority for review. At the completion of the project The Contractor shall submit one set of all MSDS sheets for all chemical materials used in the rebuild of the vehicle.

[CDR 003]

All materials utilized in the rebuild of the vehicle shall be subject to the approval of the Authority. The Contractor shall keep a running list of all materials used in the vehicle in matrix format (matrix shall contain; material name, specification or material ID number, application, approval status, correspondence number, etc.). The Contractor shall submit this matrix along with material certifications and material property test reports to the Authority for review.

[CDR 004]

The Contractor shall submit for approval joining and fastening data, specifications, and standards for all types and methods of fastening and joining used.

[CDR 005]

All name and rating plates shall be restored and permanently attached using mechanical fasteners. Fasteners shall not compromise the integrity of the enclosure. Exceptions may be made for small components and circuit boards.

All materials added shall be new and of recent manufacture. Materials approaching obsolescence shall not be used. Material, which is found to be defective and subsequently repaired, cannot be used unless specific approval is granted by the Authority.

All materials in replaced components, or added components, shall be inherently corrosion resistant, or be suitably finished with a corrosion resistant finish to minimize corrosion and degradation of appearance or function.

1.1.1 Reference Documents

The references listed in Table 19-1 are provided for convenience and shall not be construed as a complete list of all applicable references or standards. It shall be the responsibility of The Contractor to implement all applicable standards.

Table 19-1 Reference Documents

Source/Section	Title
49 CFR 223	Safety Glazing Standards--Locomotives, Passenger Cars and Cabooses
AA	Aluminum Association Standards for Aluminum Mill Products
AAR	Specifications for the Construction of New Passenger Equipment Cars
AAR	Signal Manual, Vol. 2, Section 6
AAR 2518	As Incorporated in Standard S-400 (AAR Manual E)
AAR M-201	Steel Castings
AAR M-618	High Pressure Hoses
AAR S-501	Wiring and Cable Specification
AAR S-503	Wire and Insulating Materials

Source/Section	Title
AATCC 99-2000	Dimensional Change of Woven or Knitted Textiles: Relaxation, Consolidation, and Felting
ANSI B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI B18.1.2	Square and Hex Bolts and Screws Inch Series
ANSI C37	Circuit Breakers
ANSI Z26.1	Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways
ANSI Z98.1	Steady-State Thermal Transmission Properties
Superceded by ASTM C177	
APA PS1-95	National Institute of Standards and Technology
ASME	Pressure Vessel Code
ASME B31.1	Power Piping
ASNT, TC-1A	American Society of Non-Destructive Testing
ASTM A123	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A242	Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A 269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A27	Steel Castings, Carbon, for General Application
ASTM A31	Steel Rivets and Bars for Rivets, Pressure Vessels
ASTM A488	Standard Practice for Steel Castings, Welding, and Qualifications of Procedures and Personnel
ASTM A502	Steel Structural Rivets
ASTM A514	Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
ASTM A588	Standard Specification for High-Strength Low-Alloy Structural Steel With 50 Ksi Minimum Yield Point to 4 “Thick
ASTM A606	Standard Specification for Steel, Sheet, and Strip,

Source/Section	Title
	High-Strength, Low-Alloy, Hot-Rolled, and Cold-Rolled, With Improved Atmospheric Corrosion Resistance
ASTM A666	Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
ASTM A 822	Standard Specification for Seamless Cold-Drawn Carbon Steel Tubing for Hydraulic System Service
ASTM B88	Standard Specification for Seamless Copper Water Tube
ASTM B108	Aluminum-Alloy Permanent Mold Castings
ASTM B247	Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings
ASTM B26	Aluminum-Alloy Sand Castings
ASTM B33	Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM B280	Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B456	Standard Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium
ASTM B633	Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM B85	Aluminum-Alloy Die Castings
ASTM C177	Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus (Supersedes ANSI Z98.1)
ASTM C1036	Standard Specification for Flat Glass
ASTM C1048	Standard Specification for Heat-Treated Flat Glass--Kind HS, Kind FT Coated, and Uncoated Glass
ASTM C1422	Standard Specification for Chemically Strengthened Flat Glass
ASTM C542	Specification for Lock-Strip Gaskets
ASTM D256	Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

Source/Section	Title
ASTM D2583	Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
ASTM D1055	Flexible Cellular Materials, Latex Foam
ASTM D1056	Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D1149	Standard Test Method for Rubber Deterioration-Surface Ozone Cracking in a Chamber
ASTM D1683	Test Method for Failure in Sewn Seam of Woven Fabrics
ASTM D2047	Standard Test Method for Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine
ASTM D2240	Standard Test Method for Rubber Property—Durometer Hardness
ASTM D2262	Test Method for Tearing Strength of Woven Fabrics by the Tongue (Single Rip) Method (Constant-Rate-of-Traverse Tensile Testing Machine)
ASTM D2724	Standard Test Methods for Bonded, Fused, and Laminated Apparel Fabrics
ASTM D3359	Standard Test Methods for Measuring Adhesion by Tape Test
ASTM D3512	Standard Test Method for Pilling Resistance and Other Related Surface Changes of Textile Fabrics: Random Tumble Pilling Tester
ASTM D3574	Standard Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams
ASTM D3597	Standard Specification for Woven Upholstery Fabrics-Plain, Tufted, or Flocked
ASTM D3675	Standard Test Methods for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source
ASTM D3775	Standard Test Method for Fabric Count of Woven Fabric
ASTM D3776	Standard Test Methods for Mass Per Unit Area

Source/Section	Title
	(Weight) of Fabric
ASTM D3884	Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)
ASTM D395	Standard Test Methods for Rubber Property-Compression Set
ASTM D4034	Standard Test Method for Resistance to Yarn Slippage at the Sewn Seam in Woven Upholstery Fabrics
ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension
ASTM D470	Standard Test Methods for Crosslinked Insulations and Jackets for Wire and Cable
ASTM D471	Standard Test Method for Rubber Property-Effect of Liquids
ASTM D5034	Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)
ASTM D523	Standard Test Methods for Specular Gloss
ASTM D573	Standard Test Method for Rubber-Deterioration in an Air Oven
ASTM D618	Standard Practice for Conditioning Plastics for Testing
ASTM D624	Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D695	Standard Test Method for Compressive Properties of Rigid Plastics
ASTM D746	Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D785	Standard Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical

Source/Section	Title
	Insulating Materials
ASTM D792	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM E 1354	Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using An Oxygen Consumption Calorimeter
ASTM E 1537	Standard Test Method for Fire Testing of Upholstered Furniture
ASTM E 1590	Standard Test Method for Fire Testing of Mattresses
ASTM E 424	Standard Test Methods for Solar Energy Transmittance and Reflectance (Terrestrial) of Sheet Materials
ASTM E119	Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E162	Standard Test Methods for Surface Flammability of Materials Using a Radiant Heat Energy Source
ASTM E648	Standard Test Methods for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source
ASTM E662	Standard Test Methods for Specific Optical Density of Smoke Generated by Sold Materials
ASTM F593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F1344	Standard Specification for Rubber Floor Tile
AWS A5.0	Filler Metal Procurement Guidelines
AWS C1.1	Welding Resistance - Recommended Practices
AWS D15.1	Railroad Welding Specification - Cars and Locomotives.
AWS HDBK	Brazing and Welding Handbook
AWS-D1.1	Structural Welding Code - Steel
AWS-D1.2	Structural Welding Code - Aluminum
AWS-D1.3	Structural Welding Code - Sheet Steel
CFFA-1A	Abrasion Resistance
CFFA-2	Accelerated Light Aging

Source/Section	Title
CFFA-3A	Adhesion of Coating to Fabric
CFFA-4	Blocking
CFFA-6A	Cold Crack Resistance
CFFA-7	Crocking Resistance
CFFA-15	Stretch and Set
CFFA-16C	Tearing Strength
CFFA-17	Tensile Strength and Elongation
CFFA-700	Dimensions of Coated Fabric
DIN 267	Fasteners – Technical Specifications
FAR 25.853	Air Worthiness Standards: Transport Category Airplanes, Fire Protection, Compartment Interiors
FED-STD-191	Textile Test Methods
IEC 249 (60249)	Base Materials for Printed Circuits
IEC 326-3 (60326-3)	Design and Use of Printed Circuit Boards
IEC 60077	Rules for Electric Traction Equipment
IEC 61133	Electric Traction and Rolling Stock and Test Methods for Electric and Thermal/Electric Rolling Stock on Completion of Construction and Before Entry Into Service
IEEE 1016	Recommended Practice for Software Design Descriptions
IEEE 383	Type Test for Class 1E Electric Cables, Field Splices, and Connections
IEEE 730	Software Quality Assurance Planning
ISO 3506	Mechanical Properties Of Corrosion Resistant Stainless-Steel Fasteners
ISO 898	Mechanical Properties Of Fasteners Made Of Carbon Steel and Alloy Steel
ISO 4042	Threaded Components - Electroplated Coatings
MIL-C-7438	Core Material, Aluminum, for Sandwich Construction
MIL-DTL-5015H	Connectors, Electric, Circular Threaded, AN Type, General Specification For
MIL-HDBK-349	Manufacture and Inspection of Adhesive Bonded, Aluminum Honeycomb Sandwich Assemblies for

Source/Section	Title
	Aircraft
MIL-HDBK-691B	Adhesive Bonding
MIL-P-8053	Plywood, Metal-Faced (Cancelled but used for reference)
MIL-PRF-6106	Relays, Electromagnetic, Including Established Reliability Types
MIL-STD-889	Dissimilar Metals
MIL-W-22759/6B	Wire, Electrical, Fluoropolymer-Insulated, Abrasion Resistant, Extruded TFE, Nickel-Coated, Copper Conductor, 600-Volt
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkine-Imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyamide-Insulated, Copper or Copper Alloy
NEC	National Electric Code (NFPA 70)
NEMA AB1	Molded Case Circuit Breakers
NEMA LD 3	High Pressure Decorative Laminates
NEMA LI1	Industrial Laminated Thermosetting Products
NEMA WC 70	(ICEA S-95-658) - Standard for Nonshielded Power Cables Rated 2000 Volts or Less for Use in the Distribution of Electrical Energy
NEMA WC 71	(ICEA S-96-659) - Standard for Nonshielded Power Cables Rated 2001-5000 Volts for Use in the Distribution of Electrical Energy
NFPA 130	Standard for Fixed Guideway Transit Systems
NFPA 70	National Electrical Code
SAE AMS W 6858	Welding, Resistance: Spot and Seam
SAE J403	Chemical Compositions of SAE Carbon Steels
SAE J429	Mechanical and Material Requirements for Externally Threaded Fasteners
SAE J673	Automotive Safety Glass
SAE J995	Mechanical and Material Requirements for Steel Nuts
SAE J1199	Mechanical and Material Requirements for Metric

Source/Section	Title
	Externally Threaded Fasteners
UMTA-DC-06-0152-83-1	A Corrosion Control Manual for Rail Rapid Transit

Unless a revision is specifically stated, the cited references for this Contract shall be of the latest revision available at the date of Contract award.

1.2 Units of Measure

Rebuild components shall utilize the same standards as the parent, or original item. The mounting of all carbody and truck equipment shall use the English standard of measurement.

1.3 Storage of Material

All components removed from the vehicle during the rebuild process shall be stored such that they are able to be positively identified to the vehicle and location within the vehicle from which they have been removed. All components and materials shall be adequately protected to ensure that no damage occurs during storage.

All stored material subject to corrosion shall be adequately protected by waterproof covers, coatings, or packaging to prevent damage.

Equipment covers, cable entrances, and openings shall be suitably closed to prevent ingress of water or dirt.

All dated material shall have the expiration date clearly marked. Expired material shall not be used.

Material or components, which require maintenance during storage, shall be properly maintained as per the component(s) manufacturer's instructions. The Contractor shall document such maintenance, and provide these records as requested by the Authority.

Rejected or damaged material shall be clearly marked, dispositioned, and stored separately from all other material.

1.4 Metals

1.4.1 Low-Alloy, High Tensile Strength, Structural Steel

Low-Alloy, High Tensile (LAHT) steel for the carbody shall comply with the applicable American Standard for Testing and Materials (ASTM) standard, ASTM A242 or ASTM A588 for structural shapes, plates, and bars.

LAHT hot-rolled and cold-rolled steel sheets and steel strips, with improved atmospheric corrosion resistance, shall comply with ASTM A606.

1.4.2 Heat-Treated Alloy Steel

Heat-treated alloy steel suitable for welding and other structural purposes shall comply with ASTM A514, Grade F.

1.4.3 Stainless Steel

Austenitic, stainless steel sheets, strips, plates, and flat bars shall comply with ASTM A666, except that the carbon content shall not exceed 0.03%.

Stainless steel shall be American Iron and Steel Institute (AISI) type 201, 301, 301L 302, 304, 304L, 316, 316L or 347. 301L, 304L or 316L will be used wherever stainless steel is fused (welding or resistance). Other stainless steels conforming to ASTM A 666 are acceptable for non-welded applications.

Stainless steel used in structural applications shall conform to paragraph “f” of Section 2, of Association of American Railroads (AAR) Specifications for the Construction of New Passenger Equipment Cars.

1.4.4 Steel Castings

Steel castings shall be selected for the composition, heat treatment, and design best suited for the intended service.

Weld repairs of castings shall be allowed only by the approval of the Authority, provided that repairs are performed in accordance with an approved written procedure, and by certified welders, qualified to ASTM A488.

High strength castings shall be tested, inspected, and accepted in accordance with AAR M-201.

General-purpose steel castings shall comply with ASTM A27, either Grade 65-35 or

Grade 70-36.

Low alloy nickel castings shall comply with AAR M-201.

1.4.5 Rivet Steel

Rivet steel shall comply with ASTM A31, ASTM A502, or ANSI B18.1.2. Exposed rivets shall be concentric to the shank and free from rings, pits, burrs, and deformities. If rivet holes need to be enlarged to remove corrosion or damage, then such holes shall be reamed round to the size required such that the next larger rivet may be driven accurately. Rivets exposed to view shall be Austenitic stainless steel or aluminum, as appropriate to the material being joined.

1.4.6 Aluminum

Aluminum alloy mill products shall be identified by designations prescribed by the Aluminum Association (AA) and shall comply with the requirements contained in the AA publication, "Aluminum Standards and Data."

Aluminum alloy surfaces shall not make direct metal-to-metal contact with dissimilar metals, (copper, brass, bronze, silver, nickel, lead tin, ferrous metal, etc. or alloys of these materials) except for electrical connections where appropriate joint compounds shall be used, and will be subject to approval.

The forming of aluminum parts, their joining by bolting, riveting, or welding, and protection of contact surfaces shall comply with Aluminum Company of America (ALCOA) specification, “Covering Use of Aluminum in Passenger Carrying Railroad Vehicles”.

1.4.7 Aluminum Extrusions

Extrusions, sheets, and plates shall comply with AA standards for Aluminum Mill Products, contained in Aluminum Standards and Data.

1.4.8 Aluminum Castings and Forgings

Forgings shall comply with ASTM B247 or AA standards for Aluminum Mill Products, alloy, and temper 6061-T6.

Castings shall comply with ASTM B26, ASTM B85, ASTM B108, or AA standards for Aluminum Mill Products alloy and temper 356-T6, 364-T5, or 356-T6 respectively, and shall be free from blowholes, cracks, shrinkage, and other defects.

1.5 Non-Metals

Material specifications (Technical Data & Specification Sheets) for all non-metal materials used in the vehicle shall be submitted to the Authority for review and approval**.** All non-metals shall comply with the requirements in Section 1.17, Flammability, Smoke Emission & Toxicity.

[CDR 004]

1.5.1 Elastomers

Elastomeric parts may include door and window seals, glazing strips, truck bumpers/snubbers, structural and compressible gaskets, and mounting pads.

All elastomeric parts shall be composed from suitable elastomers compounded and cured to perform satisfactorily under the intended application and the environmental conditions in which the vehicle may be operated.

Elastomeric parts shall be suitably sized for the intended application such that the fit is correct (i.e., no gaps, bulges, stress tears, etc.). Gaskets or sealing extrusions shall not bulge, kink, or spread when installed. Seams in joined, extruded gaskets shall be oriented to minimize the possibility of leakage.

Elastomeric parts used for interior decorative trim shall be colored to harmonize with adjacent surfaces. All colors shall be as approved.

Metal parts to which elastomeric materials are cured shall be made of SAE J403 hot-rolled steel or equal, suitably cleaned for bonding. Elastomeric materials shall be tested to verify compliance with performance requirements as given below. The Contractor shall submit certificates stating compliance with the requirements of the standards.

[CDR 006]

In addition to the tests indicated below, elastomers must pass the combustibility requirements as specified in the Flammability, Smoke Emission & Toxicity section of this specification.

Table 19 -2

Physical Property	Test Method	Test Value
Hardness	ASTM D2240	45 to 75, Durometer A
Tensile Strength	ASTM D412	1500 psi

Physical Property	Test Method	Test Value
Ultimate Elongation	ASTM D412	300%, min
Ozone Resistance	ASTM D1149, Type A, 7 Days, Ozone concentration 100ppm, 104°F	No cracks under 7x magnification
Oil Aging Resistance	ASTM D471, Test oil/fuel shall be representative of application, 72 hours, 158°F	+30% maximum change in volume
Permanent-Set Resistance	ASTM D395, Method a or B	25% Maximum Set
Tear Resistance	ASTM D624, Method B	300 lb/in
Brittleness Temperature	ASTM D746	Brittleness temperature no greater than -40F
Heat Aging Resistance	ASTM D573, 72 hours, 158°F	-30% change in elongation -15% change in tensile strength -5 to +15 change in hardness

1.5.2 Neoprene Foam

Neoprene foam (flexible cellular rubber products) shall be high-resiliency foam latex. Base elastomers of latex shall be polymerized chloroprene (polychloroprene) and shall contain no reclaimed rubber. The structure of the foam shall consist of a network of closed cells of uniform character. The foam shall have a high resistance to flexing, tearing, and wetting. The Contractor shall provide the physical and performance characteristics of all neoprene foam used in the vehicle.

[CDR 007]

The dimensions of flexible cellular rubber products shall comply with ASTM D1055. Foam gaskets shall also comply with ASTM D1056, Class B.

1.5.3 Fiberglass-Reinforced Plastic

Fiberglass-Reinforced Plastic (FRP) shall be polymeric-reinforced laminated material, composed of a gel-coated surface, fiberglass reinforcement, and a polyester, acrylic, phenolic, or approved equal resin.

FRP shall be able to withstand, without any physical degradation or deformation, the

stresses encountered in the environment where it is to be used. Fiberglass components shall be molded, stored, and mounted, in their final, designed, shape, and shall not be mounted in a deformed/stressed condition.

FRP shall be resistant to acids, mild alkalis, and cleaning solutions normally used in rail transit service.

Fiberglass reinforcement shall be mat, fabric, woven roving, continuous roving, chopped spun roving, or swirl mat, as required to meet physical and process requirements. Glass content by weight shall be 30% minimum. Gel coats shall be resistant to scuffing, fire, weather, perspiration, and cleaning agents and shall be pigmented to match approved colors. Gel coat must contain Ultraviolet (UV) inhibitors/stabilizers.

Gel coat additives, fillers, monomers, catalysts, activators, inhibitors, pigments, or flame proofing materials shall be added to resin mixes to obtain finished products with required characteristics. Mineral filler shall not exceed 28% of finished weight for preformed matched die molding process.

FRP shall be manufactured by one of the following methods:

Method 1: Open molding, hand lay-up, or spray lay-up (Chopper Gun)

Method 2: Matched die molding, RTM, Vacuum bag, or preform

Production techniques shall ensure that the fiberglass reinforcement is distributed throughout the final product in such a manner as to preclude resin-rich or resin-starved sections.

Open-molded parts shall be gel coated.

Surfaces shall be uniform, smooth, and free of porosity and crazing.

The Contractor shall submit for approval certificates verifying that reinforced plastic materials comply with the minimum requirements specified below. Pre-test conditioning of test specimens shall conform to ASTM D618.

[CDR 008]

Table 19-3

Mechanical Property	Test Method	Method #1	Method #2
Tensile Strength	ASTM D638	13,000 psi	18,000 psi
Compressive Strength	ASTM D695	22,000 psi	32,000 psi
Flexural Strength	ASTM D790	21,000 psi	28,000 psi
Impact	ASTM D256	10 ft-lbs/ in of notch	13 ft-lbs/ in of notch
Hardness	ASTM D2583	45 Barcol	45 Barcol
Heat	None	175°F Continuous	-
Thickness	None	0.125 in, minimum	0.125 in, minimum
Gel Coat Thickness	None	0.014" or 14 mils, ± 2 mils.	N/A

1.5.4 Thermoplastic

Thermoforming plastic material (commonly available in the form of a PVC-Acrylic material) may be used, subject to Authority approval, in the low-smoke toxicity versions commonly available for transit applications.

Thermoplastic materials shall comply the Flammability, Smoke Emission & Toxicity section of this specification, and with the following requirements:

Table 19-4

Physical Property	Test Method	Performance Requirement Value
Specific Gravity	ASTM D792	1.20 to 1.36
Hardness, Rockwell	ASTM D785	90 to 100, R-Scale
Tensile Strength	ASTM D638	5,500 psi (38 MN/m^2) minimum at 73°F (23°C)
Flexural Modulus	ASTM D790	320,000 psi (2206 MN/ m^2) minimum elasticity at 73°F (23°C)
Flexural Strength	ASTM D790	10,000 psi (68,947.6 kPa) minimum @ 73°F (23°C)
Impact Strength (@ 73°F notched IZOD)	ASTM D256	6.6 foot pounds per inch of notch minimum.
Heat Shrinkage	None	15% maximum, 10 minutes @ 380°F (193°C)
Thickness	None	3/32" (2.38 mm) minimum

1.5.5 Glass

Test reports to verify glazing material compliance per the criteria specified in this section shall be provided.

[CDR 009]

1.5.5.1 Laminated Safety Glass

Laminated safety glass shall be used exclusively and shall conform to the following general, manufacturing, and finish requirements:

a) Float glass quality shall conform to ASTM C 1036, Type 1, Class 1, quality Q3.

b) If tempered glass is used in the laminate, it shall be fully tempered in accordance with ASTM C 1422, surface compression level 3, case depth level B.

c) Edges shall be seamed and ground smooth per SAE J673, Edge no. 4, and sealed with aluminum tape or equivalent.

d) Any overlap of one sheet of glass with respect to the other at an edge shall not exceed 0.031 “(0.8 mm)

e) The thickness tolerance of the individual sheets as supplied shall be held within 0.020” (0.5 mm)

f) The dimensional tolerance for the cut size dimensions of rectangular shapes, including squareness will be according to ASTM C 1036 Table 1, but not to exceed 0.040” (1.0mm). For other shapes, the cut size shall not exceed 1/16” (1.6mm) of the dimension specified. Unspecified corners shall have a 1/16” (1.6mm) radius.

g) Masking, if used, shall be applied between the laminated layers of the glass.

h) Tinted assemblies shall use a tinted polyvinyl-butyral (PVB) layer with clear glass laminate.

i) Manufacturers stamp shall be positioned in lower right hand corner as viewed from inside the vehicle.

Window glazing shall be bonded with an approved type of plasticized PVB resin in the form of a membrane 1.1 mm (0.045”) ±10% thick, which shall not be degraded by UV or visible light or temperatures that can be obtained by solar heating

Laminated safety glass shall also conform to the requirements of the applicable classification, as follows:

Group I glass shall:

- Be clear laminated safety glass used for forward facing glazing, e.g., windshields.
- Be coated, if required, to have maximum solar transmittance of 68% according to ASTM E 424, Method A.
- Meet the requirements of 49 CFR, Part 223, FRA Type I rating, having a minimum thickness of 9/16" (14 mm).
- Be certified to comply with the requirements of ANSI Z26.1, Table 1, Item 1.

Group II glass shall:

- Be clear laminated safety glass used for operator side windows.
- Be coated, if required, to have maximum solar transmittance of 68% according to ASTM E 424, Method A.
- Be certified to comply with the requirements of ANSI Z26.1, Table 1, Item 2.
- Meet the requirements of 49 CFR, Part 223, FRA Type II rating, having minimum thickness of 3/8" (10 mm).

Group III glass shall:

- Be tinted laminated safety glass used for passenger side, and door windows.
- Be coated, if required, to have maximum solar transmittance of 34% according to ASTM E 424, Method A.
- Be certified to comply with the requirements of ANSI Z26.1, Table 1, Item 3.
- Tinted with a visible light transmission of 28% ±2%.
- Have a minimum thickness of 1/4" (6.4 mm).

1.5.5.2 Tempered Safety Glass

Tempered safety glass that may be used for internal glazing and partitions, shall be manufactured to ASTM C1048, Kind FT, Condition A, Type 1 clear, Class 1 clear, Quality q3. (or Class 3, tinted, light reducing).

1.5.6 Floor Covering

The floor covering shall be replaced in kind. The floor covering material shall contain 20% (nominal, by weight of compound) Butadiene Styrene rubber, shall be non-staining, non-discoloring and non-oil extended, and contain additives to preclude damage or discoloring to UV light.

Only high-quality hard clay shall be used as filler. No limestone shall be used in the compound.

The rubber flooring shall be fully homogeneous throughout.

At 68°F (20° C), the rubber flooring shall bend 180 degrees around a ½" (13mm) diameter mandrel without breaking, cracking, crazing, or showing any change in color.

The rubber flooring material shall comply with ASTM F1344, table 1, with tile size adjusted for maximum sheet coverage, Class 1, B, and also comply with the Flammability, Smoke Emission & Toxicity section of this specification.

The coefficient of friction of the floor rubber shall not be less than 0.60 when tested to ASTM D 2047.

The Contractor shall submit color/material samples for approval.

[CDR 010]

Prior to the installation of the floor covering, any depressions, voids, or cracks in the sub-floor shall be filled and the sub-floor shall be leveled and smoothed with an Authority approved leveling compound.

The floor covering shall be permanently secured to the sub-floor with an approved adhesive and as recommended by the flooring manufacturer. The bottom side of the flooring shall be sanded and then securely bonded to the sub-floor panels. The floor covering and adhesive shall be resistant to cleaning solutions and solvents normally encountered in rail transit service.

There shall be no tears or cracks allowed in the installed floor lining, non-penetrating defects such as blisters, lumps, craters, and deformations shall be no greater than 0.030" (0.76mm) in height difference from the nominal, surrounding rubber thickness, and shall occur no more than the following:

- Defect diameter ≥ 1" – Not permitted.
- 1" > Defect diameter > 1/4" – 1 each every 6 feet allowed, but must be repaired.

- Defect diameter ≤ 1/4" – 3 per 12"x12" square area allowed, with no others closer than 3 feet.

1.5.7 Marking Films & Graphics

All graphic materials shall be transportation grade materials. Signage graphics shall have an opaque background with clear, vandal resistant overlayment such as polyvinyl fluoride or polycarbonate. Printed graphics shall be either reverse printed on the back of the clear overlayment, or printed on opaque background and covered by the clear overlayment. The Authority shall approve all materials, graphic construction, and fixing method.

Application techniques shall be in accordance with manufacturer's recommendations.

Physical Properties of Graphic Material

- Lettering or striping film shall be sufficiently opaque so that, when applied, the film shall completely hide any contrasting background and shall be readily legible.
- There shall be an initial 60-degree gloss value of 40 when tested in accordance with ASTM D523.
- Films shall retain adhesive properties after one week of continuous exposure to a temperature of 66°C (150°F).
- Films shall be able to conform to moderate contours of the vehicle's interior and exterior surfaces at locations where applied.
- Overall thickness of processed film shall be between 0.004" and 0.008" (0.10 mm and 0.20 mm), multiple layer graphics may be up to 0.020" total thickness (excluding mounting adhesive thickness).
- Films shall withstand immersion in either distilled water or SAE No. 20 motor oil for 24 hours at temperatures of from 70°F to 90°F (21°C to 32°C) without any appreciable degradation in adhesion, color, or general appearance.
- Marking films shall withstand effects of detergents and brushes used in washing procedures for removal of graffiti.
- Films shall use a removable grade adhesive that upon removal does not require use of solvents, or secondary operations to remove adhesive or graphic residue.
- Square or rectangular graphics shall have rounded corners of suitable

radius to prevent the lifting or curling of corners.

Graphic material used for vehicle striping shall be 3M 690 Plus (Flexible Reflective Sheeting) or Authority approved equivalent.

1.6 Structural Panels

Sandwich panels include, but are not limited to, plymetal, honeycomb, or lumber-core panels, with metal or other approved facing material.

Melamine, high pressure laminates used in the construction of the vehicle shall be two-ply laminated and shall consist of a hard plastic film facing permanently bonded to base sheet.

Contact adhesives shall not be used to bond the melamine to the base.

The final laminate assembly shall comply with NEMA LD-3, General Purpose Type, and comply with the Flammability, Smoke Emission & Toxicity section of this specification.

1.6.1 Honeycomb

When finished, continuous edge reinforcement shall be incorporated if needed to facilitate transfer of stresses and to seal edges against moisture penetration and other damage. Where mechanical fasteners are used, threaded inserts shall be bonded into the panel.

The term “honeycomb panels” as used in these Provisions, refers to honeycomb material bonded to melamine or metal.

Honeycomb-core panels shall comply with applicable requirements of MIL-C-7438G, and MIL-HDBK-349, unless otherwise specified.

Bonding between the base material and the cover shall be sufficient to develop the full strength of the honeycomb material. The Contractor shall demonstrate by test and analysis, that the honeycomb panel design selected for a particular application, is adequate for the intended purpose.

1.6.2 Plywood & Plymetal

All plywood shall comply with National Institute of Standards and Technology (NIST), APA PS1-95, Exterior Grade B-B, High Density Overlay. Floor panels shall be a minimum of 5/8” (16mm) thickness.

Plymetal panels for floor construction shall be faced on both sides and at all edges

with stainless steel (wrapped). All plymetal panels shall have the metal seams bonded together.

All exposed edges of the panels, drilled holes, fastener heads, openings, or cutouts within the panels shall be waterproofed and sealed with an approved epoxy paint/coating as soon as possible after fabrication, and prior to installation.

Each plywood panel shall be formed from one piece. Jointed panels shall not be allowed.

Plymetal panels shall also meet the following test criteria:

Table 19-5

Minimum Metal to Wood Test*	Minimum Value
Dry Shear	250 lbf/in.^{2} (1.72N/mm^2) to 80% wood failure
Boil shear, 3 hrs boil, tested at 68°F	150 lbf/ in.^{2} (1.03N/mm^2) to 80% wood failure
Wet shear, 48 hrs. soak, 68°F	150 lbf/ in.^{2} (1.03N/mm^2) to 80% wood failure
Creep, under static load for 48 hrs, 68°F	250 lbf/in.^{2} (1.72N/mm^2) to 80% wood failure

* The plymetal test reference refers to inactive standard MIL-P-8053.

1.6.3 Panel Flatness

The overall flatness shall not exceed a maximum deviation of 0.015" per lineal foot, with a maximum of 0.125” deviation of any point on the panel measured from a reference plane taken from any three corners. The overall deviation of the panel thickness shall not exceed 0.031" (1/32").

1.7 Fastening / Joining

Unless otherwise specified, screws, rivets, mounting bolts, or similar items shall be replaced in kind. The use of exposed fasteners on the vehicle interior shall be minimized. Interior fasteners shall be countersunk where possible, or low profile heads shall be used where countersinking is not possible. Interior fasteners shall not protrude enough to become a tripping or snagging hazard.

1.7.1 Fastening to Structural Members

Fastening to structural members shall be done only on the low stress portion of the member and shall not be located within 3/4" (17mm) from the open edge of the structural member.

The Contractor shall ensure that any fastening or joining to structural members does not result in moisture accumulation within any structural member. To this end, fastenings to hollow, closed section structural members shall not be accomplished using drilled holes in the structural member.

1.7.2 Threaded Fasteners

The number of different sizes and styles of fasteners used shall be minimized. A single standard, e.g., Metric (DIN/ISO) or US (ANSI/SAE/IFI)(preferred), shall be adopted for the fasteners used. Fasteners shall be properly marked per the system adopted. All threaded fasteners shall comply with ANSI B1.1 class 2 requirements, unless otherwise specified or approved. All structural threaded fasteners shall have rolled threads.

Self-tapping or thread forming screws may be used with Authority approval only, on a case-by-case basis.

Use of threaded inserts or special or non-standard fasteners shall require Authority approval.

At least 1 1/2 threads shall be visible beyond all nuts. Bolts smaller than 0.25" [6 mm] shall not project more than 1 1/2 thread plus 0.25" [6 mm]. Bolts 0.25" [6 mm] or larger shall not project by more than eight (8) threads.

Fasteners exposed to public view shall be treated as follows:

- On the vehicle interior, all exposed fasteners shall be stainless steel (Grade 316), with flat or oval heads, properly countersunk.
- On the vehicle exterior, all exposed fasteners shall be stainless steel.
- Exposed screws shall be "Pin in Head" Torx tamper-resistant type and approved by the Authority.

Fasteners not exposed to passengers on the vehicle interior shall be of stainless steel (Grade 316).

Fasteners and fastener components used on the vehicle underfloor or roof areas shall be stainless steel (Grade 316) except in cases where high strength fasteners such as

SAE grade 8 or metric Property Class 12.9 are required. Underfloor fasteners ½" diameter or larger may be plated steel of the same grade they replace. The Contractor shall provide a list of all threaded fasteners, fastener classification, material, finish, and location used, for Authority approval.

[CDR 011]

1.7.2.1 Fastener Materials

Fastener component materials (screws, nuts, washers, etc.) shall be properly selected for the application and shall not be mixed within an assembly. All fasteners shall be stainless steel, or unless otherwise specified, steel finished with protective coating such as passivation, dichromate, or zinc plating, depending on the specific application.

Threaded aluminum fasteners shall not be used, except in tapped holes in solid aluminum structures, and are subject to approval.

Stainless steel nuts and bolts shall be used for stainless-to-stainless joints. Anti-seize compounds shall be used on all stainless steel fasteners threaded into stainless steel, or using stainless steel nuts.

US Standard

Threaded fasteners shall conform to current SAE J429 standards for externally threaded fasteners and SAE J995 standards for internally threaded fasteners. Steel fasteners ¼" diameter and above shall be SAE Grade 5 minimum.

Stainless steel fasteners shall be manufactured from austenitic stainless steel alloys, according to ASTM F 593, with a nominal tensile strength of 100 ksi. All fasteners shall be clean and free of manufacturing scale.

Non-structural screws, such as Phillips or slotted head screws smaller than ¼" diameter, may be SAE Grade 2 minimum.

Metric

Carbon steel Metric threaded fasteners shall conform to SAE J1199, or the current equivalent, specified, DIN or ISO standards. Carbon steel fasteners 6mm diameter and above shall be Property Class 8.8 minimum for external threads, Property Class 8 minimum for nuts, per ISO 898/1 and ISO 898/2.

Stainless steel fasteners shall be manufactured from A2 or A4 grade, austenitic stainless steel with a minimum Property Class of 70 per ISO 3506-1979, with a

minimum nominal tensile strength of 700 MPa.

Non-structural screws, such as Phillips or slotted head screws smaller than 6mm diameter, may be Property Class 4.8 minimum for steel, Property Class 50 for stainless steel. Manufacturing tolerances shall be according to DIN 267, Part 2, “m” (medium class)

1.7.2.2 Locking Requirements

All threaded fasteners shall be self-locking or provided with locking devices. Locking devices shall be lock wire, lock washers, torque patch, or prevailing torque type locknuts as appropriate for the application or service. Lock wire, if used, shall be aircraft grade stainless steel.

Prevailing torque locknuts shall be of the nylon collar insert type. Previously installed and removed locknuts shall not be re-used. High temperature applications may use metallic distorted thread locknuts upon Authority approval.

Unless specifically approved by the Authority, bolts for use with locknuts shall not be drilled for cotter pins or in heat related applications.

All locknuts shall comply with the Industrial Fasteners Institute requirements regarding locking ability.

When oversized or slotted holes are provided for installation tolerance allowance, flat washers, of suitable size to cover oversized holes, or slots shall be used in all locations adjacent to the hole. In this case, at least one hole shall be of close tolerance to ensure accurate positioning of component. If slotted holes are provided as a means of adjusting a piece of equipment, a secure method of fixing the adjustment shall be provided, such as adjustment screws, ribbed or toothed adjustment washers, drilled holes and pins, etc.

1.7.2.3 Plating & Treatment of Fasteners

All steel fasteners shall be zinc plated with the highest protective service condition available per thread configuration. Stainless steel fasteners shall be passivated. Chrome plated, steel fasteners used for interior, cosmetic applications shall be chrome plated per ASTM B 456, class SC-3. If stripping and re-plating of fasteners is required to meet the aforementioned criteria, documentation must be made available to verify that all applicable post plating treatments and standards have been met. The Authority may require batch testing of stripped and re-plated fasteners to ensure there is no hydrogen embrittlement.

US Standard

After manufacturing, steel fasteners shall be electroplated, zinc with a yellow chromate conversion per ASTM B633, Type II - Yellow (please refer to table for thickness).

Metric

After manufacturing, steel fasteners shall be electroplated, zinc with a yellow chromate conversion per ISO 4042, (please refer to table for thickness).

Table 19-6

Plating Thickness for Steel Fasteners, Zinc, Yellow Chromate Conversion			
Bolt size	Metric DIN 267	US ASTM B633	Thickness (Micro meter / inch)
Dia, up to #8 (M3)	A1L	-	3µm / .00012"
Dia. >#8 (M3) to 5/16" (M8)	A2C or A2L	SC1	5µm / .00020"
Dia. >5/16" (M8) to 7/8" (M22)	A3C	SC2	8µm / .00031"
Dia. >7/8" (M22) to 1-1/8" (M33)	A4C	SC3	13µm / .00051"
Dia. >1-1/8" (M33) and greater	A5C	-	15µm / .00059"

Hydrogen Embrittlement

Fasteners or fastener components with hardness greater than or equal to 320 HV (32 HRC) are susceptible to hydrogen embrittlement when pickled and/or electroplated. This may cause these fasteners to fail at relatively low loads even if stress relief annealing (baking) is performed after plating. Examples of hardened fasteners are steel bolts - US Grade 8 (Metric Property Class 10.9), hardened steel washers, spring washers, etc. These types of fasteners shall be mechanically plated to avoid hydrogen embrittlement.

1.7.2.4 Torque Marking/Indexing

The Contractor shall ensure the proper application of all threaded fasteners.

Torque marks or stripes extending from the secured hardware to the surrounding surface shall be applied to all safety related hardware, including truck, door, and brake equipment bolts.

Tightening indication may be required on other non-safety related hardware upon the Authorities' request.

1.7.2.5 Bolts and Nuts

All threaded fasteners falling into this category used in this project shall require a submittal of Certifications of Compliance (C of C) with each shipment of hardware to the end user. The C of C shall be traceable to a manufacturer.

1.7.2.6 Electrical and High Temperature Connections

Plated steel screws or bolts, nuts, flat washers, and lock-washers used in mounting and in making connections to resistors and other heat-producing apparatus shall be suitable for high temperatures without degradation of the strength or stretching of the hardware or its corrosion resistance.

Flat washers shall be used on both sides of all electrical connections (under bolt head and under nut). Spring washers shall be used on the nut side of all electrical connections.

1.7.3 Riveting

Rivet holes shall be accurately sized, located, and aligned for the intended rivet. Rivet holes that have been repaired, or the rivet removed shall be reamed to the next larger rivet size, and the next larger rivet installed. Rivets exposed to passengers on the outside of the vehicle shall be stainless steel.

Hand-driven steel rivets shall be driven hot and shall completely fill the holes.

Two part rivets consisting of a pin and collar (such as Huck-Bolt types) shall be installed such that the pin breaks flush with the end of the collar.

Blind rivets may be used subject to Authority approval. Blind rivet materials may be stainless steel, or plated carbon steel with plated steel or stainless steel mandrels compliant with SAE J1200. The mandrel shall break flush or slightly below the surface of the rivet head, but shall remain locked in place as a structural part of the rivet assembly. All rivets shall be installed according to the rivet manufacturer's instructions, using equipment approved by the rivet manufacturer.

Rivet nuts shall be of the positive locking variety. The rivet nut hole shall be made per the rivet nut manufacturer’s recommendations.

Aluminum alloy rivets shall comply with AA standards for Aluminum Mill Products

alloys and tempers 6061-T6 or 6053-T61.

1.7.4 Welding

All welding not specifically covered in this Section shall be in accordance with the applicable requirements and recommendations of the American Welding Society (AWS), as contained in the latest revisions of the "Structural Welding Code" (AWS D1.1), "Aluminum Welding Code" (AWS D1.2), "Structural Welding Code - Sheet Steel" (AWS D1.3), "Recommended Practices for Resistance Welding" (AWS C1.1), "Railroad Welding Specification" (AWS D15.1) and the AWS "Welding Handbook" (AWS WHB). Where non-AWS welding is used, the supplier shall demonstrate equivalence. The Contractor shall demonstrate compliance with AWS welding requirements and standards.

[CDR 012]

The Contractor shall be responsible for the quality of all welding and brazing, including the welding and brazing of its suppliers and Sub-contractors.

Prior to welding, all surfaces shall be thoroughly cleaned to remove corrosion, rust, scale, slag, grease, oil, water, paint, and other foreign materials in accordance with applicable parts of AWS D1.1, Section 8.5 on Workmanship and Technique.

Parts to be joined by welding shall be supported and held in position by tables, jigs, or fixtures to prevent warping. Weld joint design and welding method shall be selected to include provisions for shrinkage and warping due to the welding process. Welding shall be applied in a manner to minimize distortion. Acceptable distortion levels shall be submitted for Authority review and approval.

All weld quality shall be in accord with acceptable weld criteria as defined in AWS welding Codes. The Contractor shall submit welding procedures specifications (WPS), and welder certifications for approval.

[CDR 013]

1.7.4.1 Welder Certification

Each welder shall be tested and certified to verify their proficiency for producing sound welds, for each weld type performed.

Welder qualification tests shall be performed in accordance with the applicable requirements of AWS standards, or other approved equivalent standards. Welder qualification tests for pressure vessel welding shall be in accord with applicable

requirements of ASME Section IX, or other approved specifications. The Contractor and all suppliers and Sub-contractors shall retain records of welder qualifications and shall make these records available to the Authority upon request. Welders shall meet all requirements, including conformance with drug testing.

The Authority shall have the right to require the making of test welds by any welder, whether under the direct control of The Contractor or a supplier or Sub-contractor, to ascertain his/her competence and to determine the suitability of the welding procedure used.

1.7.4.2 Welding Procedures

All welding practices not specifically covered in other sections shall comply with AWS-D1.1, AWS-D1.2, or AWS-D1.3 and the AWS Welding Codes as appropriate.

Requirements for dynamically loaded structures shall be applied.

Resistance welding shall be in accordance with SAE-AMS-W-6858. Resistance welding operations shall be undertaken using only equipment fitted with meters or readouts and adjustments for time, current, and pressure.

The method used in depositing weld metal shall be one that reduces warping and residual stresses. To achieve this, tack welding, offset welding, skip welding, and other devices and sequences well known to the craft shall be used where appropriate.

Machine welds of any thickness may be made with one or more passes as per the Procedure Qualifications Record (PQR) for the weld joint.

The Contractor shall submit a PQR for all weld joints to be used or pre-qualified per AWS codes and all Weld Procedure Specifications (WPS) for the project.

[CDR 014]

Procedures used for the welding of metal combinations not specifically covered by the AWS standards (e.g., stainless steel to steel) shall be approved by the Authority. Stainless steel to steel welds shall use austenitic stainless steel filler metal.

1.7.4.3 Welding Electrodes

The choice of welding rod or wire filler metal shall be made with consideration of the make, type, size, composition, and suitability to the application and shall be in accordance with "Specification for Filler Metal" AWS A5.0.

Welding electrodes shall be stored in a dry, closed environment to prevent

contamination in accordance with AWS recommended practices for filler material storage. Welding electrodes shall be clearly marked and dated.

1.7.4.4 Weld Repairs

Weld repairs shall be performed in accordance with approved procedures, which comply with AWS D1.1 or the AWS Code applicable to the welded material.

When a production weld has been determined to be substandard, all production since the previous acceptable production quality control test shall be segregated, and disposition shall be recommended to the Authority for approval. All parts with substandard welds shall be rejected or repaired by weld removal, re-weld, and inspection.

1.7.4.5 Welding Inspection and Examination

The Contractor shall inspect all welds. Welds shall be inspected to verify compliance with these provisions and specifications.

Welding inspection procedures and welding inspector qualification tests shall be performed in accordance with the applicable requirements of the AWS standards for weld inspection.

The Contractor shall use and demonstrate the use of personnel qualified to perform weld inspection. An AWS Certified Welding Inspector (CWI) shall be utilized for inspection or oversight of welding inspection.

Non-destructive examination and testing of welds and welder qualification tests shall be performed in accordance with the applicable requirements of the AWS Welding and Brazing Handbook.

Personnel performing Non-Destructive Testing (NDT) shall have documented qualifications in accordance with American Society of Non-destructive Testing (ASNT), TC-1A.

In addition to visual inspection requirements specified by the AWS welding codes, non-destructive surface inspection (dye penetrant or magnetic particle methods, as appropriate) shall be used to inspect all first-production welds.

The Contractor shall specify additional non-destructive inspection requirements for subsequent welds. If The Contractor elects to inspect less than 100%, then The Contractor shall submit a random sampling inspection plan for approval by the Authority. In no case shall the length of weld non-destructively inspected be less than

1% of the total weld length.

All welds designed to carry primary stresses in members such as side sills, end frames, bolsters and other important truck and frame members, shall be inspected by The Contractor for defective welding.

Critical areas of all such welds shall be magnetic particle, dye penetrant or ultrasonic tested. Radiographic tests shall be used on a random sample basis.

The following defects in excess of limits indicated or established, in the approved procedures shall be cause for rejection of the work affected:

- Cracks, regardless of length, magnitude or location
- Overlaps
- Lack of penetration
- Incomplete fusion
- Inclusions, except if they do not materially affect the strength of the welded joint and do not indicate improper technique or an unsatisfactory procedure
- Undercuts
- Poor surface appearance; or improper size of weld

On the first structure or component, all full-penetration welds shall be non-destructively, volumetrically inspected (ultrasonic or radiographic methods). The Contractor shall specify a random sampling plan for volumetric inspection of subsequent full-penetration welds for approval by the Authority.

With the approval of the Authority, destructive sectioning and metallurgical examination may be substituted for some or all of the required volumetric inspection requirements.

1.7.4.6 Heat Treatment

Where required by specifications or drawings, welded assemblies shall be stress-relieved by heat-treating in accordance with AWS D1.1. Chapter 4, Part A.

Heat treatment procedures shall be documented and submitted for review for first piece/part processing.

All heat treatment documentation (results) shall be retained by The Contractor.

1.7.5 Brazing

The Contractor shall maintain a brazing program similar to the welding program specified in the welding portion of this specification.

All brazing, qualification of brazers, and repair of brazing defects shall be in accordance with the requirements and recommendations specified in the AWS Welding and Brazing Handbook.

The Contractor shall maintain quality control procedures necessary to ensure high-quality brazing. The Contractor shall submit brazing specifications, procedures, and certifications for approval.

[CDR 015]

1.7.6 Soldering

Soldering of electronic equipment shall comply with the requirements of ANSI J-STD-001B. The Contractor shall submit soldering specifications, procedures, and certifications for approval.

[CDR 016]

1.8 Piping, Tubing & Pressure Vessels

Air or hydraulic hose applications shall not be permitted in locations where adequate visual inspections cannot be made. Hose installations shall be located/arranged in such a manner as to prevent accidental cross connections to other hoses located in the same general area.

Hose installations shall be such that kinking, rubbing, straining, and unnecessary swinging are precluded. Routing that requires other piping, or cables, as the sole means of support shall not be accepted.

The Contractor shall perform a leak test on the final air or hydraulic piping system, with all components installed and operational, on each vehicle in accordance with IEC 61133. The Contractor shall submit a copy of the test procedure for approval. A copy of the test report for each vehicle, including retest reports if appropriate, shall be included with each Vehicle History Book.

[CDR 017]

Loss of main reservoir air pressure due to cumulative leakage in the entire pneumatic system, not including that required for system functioning, per vehicle, shall not exceed

10 psig in 15 minutes, following a 5-minute settlement period from the point at which the system was fully charged and the air compressor was shut off.

The Contractor shall submit piping, tubing, and pressure vessel specifications and data for approval.

[CDR 018]

1.8.1 Piping and Tubing

Piping and tubing shall be adequately supported at least every 24” [610 mm] throughout its length and at connections, and must not interfere with the removal of or access to other components. A minimum clearance of 0.125” [3 mm] shall be maintained on all piping and tubing used in the vehicle. Attachment shall be by securely fastening with elastomeric or polymeric lined, steel clamps, or an approved equivalent, between the pipe and clamp to prevent chafing and vibration.

All piping shall be seamless stainless steel per ASTM A269, or carbon steel per ASTM A822, as determined by the application.

Stainless steel fittings must be used with stainless steel piping and tubing. Forged steel fittings, zinc plated to ASTM B633, Type II, Yellow, SC3 / SC4, may be substituted upon Authority approval. Forged steel fittings, zinc plated to ASTM B633, Type II, Yellow, SC3 / SC4, shall be used with carbon steel tubing. After assembly, fittings shall be treated with a corrosion resistant coating.

All tubing ends shall be properly formed for the system selected; flared ends shall be machined formed, compression style bite rings shall be pre-set using a machine recommended by the fitting manufacturer. The fittings shall be assembled onto the tubing per the manufacturer’s recommendations.

All piping, tubing, valves, fittings, installation and testing methods, shall comply with ASME B31.1.

Copper tubing may be used with Authority approval, and shall be seamless per the standards for: Copper tubing used for refrigeration purposes per ASTM B280 or equivalent, or Copper tubing used for pneumatic purposes per ASTM B88, type "K" annealed, or equivalent. Copper tubing fittings shall be sweat type of wrought copper or cast brass.

Joints that serve the sole purpose of connecting straight runs of pipe shall not be used. Unavoidable joints in piping shall be made in an approved manner. All inaccessible runs of tubing or piping shall be without joints.

Piping segments shall be deburred and blown out after cutting, thoroughly cleaned and capped after fabrication. The Authority reserves the right to verify piping cleanliness meets the Authority's satisfaction at any time during the production process.

After full installation on the vehicle, and before connection or installation of system components, the piping system shall be completely flushed with a suitable liquid solution, using appropriate pressure and velocity to fully dissolve all contaminants from manufacture and installation. The piping systems shall be cleaned a second time, following completion of component installation, using approved procedures. The Contractor shall submit for approval proposed flushing and cleaning procedures for the piping and piping system.

[CDR 019]

Following installation, piping systems shall be pressure tested in accordance with ASME B31.1 or other approved method. All leaks, which appear during pressure testing, shall be repaired to the Authorities' approval and re-tested until acceptable under the approved test criteria.

All hoses used shall comply with AAR M-618. All hose fittings shall be of an approved reusable type. Iron pipe fittings used with steel piping shall be AAR approved, with additional corrosion resistance as approved by the Authority.

All piping shall be installed in accordance with AAR 2518 as incorporated in Standard S-400 (AAR Manual E) and in such a manner as to provide drainage to prevent freezing.

1.8.2 Filters

The filtering capability, flow rate capacity, and overall size of filters shall be appropriate for the application so that the filter replacement interval shall be greater than 6 months. The filter element shall be a common production type, commonly available through multiple sources.

Access to the filter element for replacement purposes shall be possible without requiring the opening of any pipe fittings. Filters shall not be located in inaccessible locations for routine maintenance access.

1.8.3 Pressure Vessels

Unfired pressure vessels shall comply with Section VIII and IX of the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels. A test report shall accompany

each pressure vessel received by The Contractor, and a copy of the test report shall be included in the appropriate Vehicle History Book. Each pressure vessel shall be stamped by the testing facility, whether it is the manufacturer or a third party, as verification of unit testing.

Drain cocks shall be provided at the low points of all reservoirs.

1.9 Bearings & Lubrication

All bearings and lubricants shall be readily available in the continental United States. All replacement bearings shall be of the same type and of the same quality and life expectancy as the OEM equipment.

All rotary shafts shall be supported by cylindrical or tapered roller bearings where practicable. Ball bearings may be used, subject to approval. Rotary / Motor shafts shall be suitably protected against corrosion to allow unencumbered removal of bearings.

Bearings subject to atmospheric or liquid contamination shall be sealed by labyrinth, lip, or face seals. Bearings installed in a vertical application shall have suitable protection to prevent moisture or contaminants from accumulating on, or entering the bearing.

Bearings that are not splash- or bath-lubricated shall be provided with standard grease fittings and drain plugs or pressure-release devices for re-lubrication. Ball bearings of 1” [25 mm] shaft size and smaller may be factory lubricated-for-life, subject to approval.

Bearings shall be installed and removed without major disassembly of related components. Thrust style bearings shall be used whenever there is an axial load on the rotating shaft carried across rolling elements.

Self-lubricated bushings (sintered metal) shall be used in accordance with the manufacturer's recommendations, but shall not be used for shafts with speeds greater than 500 rpm.

The Contractor shall submit bearing specifications and data for approval.

[CDR 020]

All lubricants shall be products approved by the supplier of the parts on which the lubricant is to be used. All lubricants shall, as a minimum, conform to applicable ANSI and ASTM specifications. Multi-purpose lubricants shall be used where possible. The Contractor shall submit for approval, data on lubricants recommended for bearings and bushings and a lubrication schedule.

[CDR 021]

1.10 Corrosion Control

All materials used shall be either inherently corrosion resistant, suitably treated, or coated to resist corrosion. Equipment located in areas highly susceptible to corrosion shall be made from inherently corrosion resistant materials.

Areas exposed to corrosive fluids, materials, or cleaning solutions shall be protected with coatings resistant to those fluids. The Contractor shall be responsible for verifying that all such areas are protected through communications with the Authority.

Except as otherwise indicated, all aluminum exposed to view in finished work in the interior of the vehicle shall have a protective anodized coating.

The recommendations contained in "Corrosion Control Manual for Rail Rapid Transit", UMTA-DC-06-0152-83-1, shall be used, except as otherwise directed by the Authority.

The Contractor shall prepare a Corrosion Control Plan, which shall locate all materials that require treatment to prevent corrosion due to atmospheric exposure, and areas of dissimilar metal or other material joining which could result in galvanic action and material deterioration. This plan shall document the methods used to preclude failure due to corrosion for any of the above conditions. The Contractor shall update this document as materials and treatments change. The Corrosion Control Plan shall be submitted to the Authority for review and comment.

[CDR 022]

1.10.1 Dissimilar Metal Treatment

All metals used in the fabrication process shall be surface treated with corrosion-resistant materials prior to assembly, with consideration being given to the severity of exposure to which the surface shall be subjected.

The joining of incompatible metals and materials shall be minimized as much as possible. When such metals must be joined, provisions shall be made in accordance with MIL-STD-889 to prevent chemical reactions between the dissimilar metals.

Surfaces of aluminum alloy parts secured to ferrous parts shall be protected with one-part polysulfide or non-corrosive silicone sealant used as joint compound, or with joint material that is non-hygroscopic and is free from chlorides and heavy metal ions.

Fibrous joint material shall be impregnated with bitumen or other water-repellant substance, which shall completely cover interfacing surfaces.

All ferrous metal surfaces, other than stainless steel, shall be protected by painting or

zinc plating as defined in this specification, unless otherwise specified. Steel surfaces not requiring protection shall be galvanized by the methods and requirements described in ASTM A123. Minor damage to galvanized coatings shall be repaired with an approved zinc rich paint.

The Contractor shall submit for approval a description of the procedures and processes employed to prevent corrosion arising from the use of dissimilar metals.

[CDR 023]

1.11 Cured Materials

All materials that are applied prior to curing shall be applied according to the manufacturer's full recommendations, including surface preparation, mixing criteria, application temperature, shelf life limits, pot life limits, curing temperature, curing exposure (before handling, or loading), etc.

All uncured material shall be stored and applied according to the manufacturer's full recommendations. All materials shall be used within the specified shelf life limits; material that has exceeded the shelf life shall not be used.

1.11.1 Paint & Primer

All paint must be compatible with the Authorities' present paint application apparatus and system, and must be fully repairable within the parameters of restrictive air quality zones and the local, governing air quality management authority. The Contractor shall submit for approval data on all paints, primers, and application processes or procedures to be used for the Authorities vehicle. The undercoating material shall be applied according to the manufacturer's instructions.

[CDR 024]

All dents, roughness, or other surface imperfections shall be corrected prior to the application of the priming coat.

Primer, finish paint, and related components shall be supplied as a complete system, manufactured by a single manufacturer. All mixed paint materials shall be used within the first 70% of the mixed pot-life time. Paint shall be applied within the manufacturer's recommended temperature range, but at a temperature no less than 55°F.

Preparation for primer and paint application shall follow the manufacturer's recommendations. As a minimum, prior to paint application, surfaces shall be cleaned

to remove all traces of contamination, and properly treated to promote paint adhesion.

Paint shall be applied evenly, and the finished surface shall be free of dirt, runs, "orange peel", overspray, or other imperfections. Paint inspection and acceptance criteria subject to Authority approval. Paint quality control samples may be proposed to establish visual acceptance criteria, subject to Authority approval.

Cosmetic coatings of paint shall have specified gloss levels for the appearance desired. The following gloss levels are defined according to common terminology, with the following criteria based upon the ASTM D 523 – 60° axis angle with equivalents shown for 80° and 20°.

Table 19-7

Gloss Level Definition	Glossmeter Setting and Gloss Value		
	20 degree	60 degree	85 degree
- High Gloss	85-90%	90-95%	95-100%
- Semi Gloss	0-10%	20-30%	50-60%
- Flat Gloss	0%	0-10%	10-20%

At least two (2) coats of finish paint shall be applied, with manufacturer's recommended surface preparation between coats.

All primer and paint damaged during the rebuild process shall be repaired as per the manufacturer's recommendations.

Touch-up paint shall be identical in all respects to the original paint. Color chips for color match may be provided by The Contractor for Authority approval, to establish acceptable color match tolerances. It is The Contractor's responsibility to ensure that the color match is acceptable. It may be required that the color match be made according to ASTM D 2244. In no case shall color mismatch detract from the overall appearance of the equipment/vehicle.

Prior to assembly, all low-alloy steel areas shall be painted with one coat of an approved etching primer followed by one coat of an approved sealer to prevent rusting.

All coatings used are to be EPA compliant.

Painted surfaces shall develop full adhesion to the substrate for which they are applied. Testing for adhesion between the paint and the substrate surface will be done on a random basis and shall conform to ASTM D 3359, 3a Classification, using

Permacell® #99 adhesion test tape.

1.11.1.1 Carbody Exterior

The carbody exterior shall be painted with an automotive quality urethane paint system consisting of primers and color coat as approved by the Authority. Exterior surfaces, except the underframe and underside of the flooring, shall receive a minimum of two (2) coats of primer, a coat of surfacer, and a minimum of two (2) coats of color.

Areas subject to excessive corrosion, such as under-glazing strips and door seals, shall receive two (2) coats of primer and two (2) coats of color.

Roof

Corrugated roof stainless steel sections shall not be painted.

Other roof sections shall receive a minimum of two (2) coats of primer, a coat of surfacer, and at least two (2) coats of color.

Roof walkway areas, either on the car structure or equipment containers, shall have an anti-skid material, coating or surface application to provide a safe walking surface when wet or covered with ice and snow.

Underfloor

Exposed underfloor steel surfaces, after installation of welded-on bracketry, shall receive a minimum of two (2) coats of primer and two (2) coats of an approved undercoat paint. In areas where intermittent welding is used, the seam shall be completely sealed after paint application.

1.11.1.2 Equipment Enclosures

The exterior of all equipment enclosures shall receive a minimum of two (2) coats of primer, and a minimum of two (2) coats of an approved paint.

The interior of all equipment enclosures shall be coated with a primer and an approved white coating. Electrical equipment enclosures shall use an approved, non-conductive, white, epoxy coating.

1.11.1.3 Exposed Piping, Conduits and Wireways

The Contractor shall ensure that wireways, conduits, and piping that can be corroded

shall receive a minimum of two (2) coats of primer and two (2) coats of an approved paint.

This priming and painting can be accomplished either before or after installation of the item on the carbody.

1.11.1.4 Undercoating

Undercoating material specifications shall be submitted for Authority approval The undercoating shall remain functional throughout the service life of the vehicle.

The undercoating material shall be applied according to the manufacturer's instructions. Undercoating thickness shall conform to the manufacturer's recommended practices.

The composition of the materials selected for the protective treatment system shall be such that treated members may be readily cut or removed using conventional cutting methods, such as burning or sawing, without creating any fumes hazardous to employees.

Undercoating shall be applied following priming and painting.

1.11.1.5 Painting and Undercoating Restrictions

Any component that would be damaged or suffer impaired performance from painting or undercoating shall not be painted or undercoated. These items include, but are not limited to the following:

- Wire, cable, flexible conduits and fittings, electrical grounding points
- Wearing surfaces, threads used for adjustments, lubrication points
- Elastomeric parts, hoses, bumpers, etc.
- Heat transfer surfaces, resistors, electrical insulators, etc.
- Moving parts, linkages, gas springs, etc.

1.11.2 Powder Coating

Powder coating if used, shall be epoxy based for interior surfaces and polyester based for exterior surfaces. Finished film thickness shall be 3.5 mil (0.089mm) ± 1.0 mil (0.025mm). The surface preparation and pre-treatment shall be according to the powder manufacturer’s recommendations.

Powder coating finish gloss level for cosmetic surfaces shall be according to Powder

Coating Institute, Gloss Level Standard(s) – 7 to 10.

1.11.3 Adhesives

Adhesives to be used for installation of floor covering, panels, insulation, and vibration isolation materials shall have a satisfactory history of performance in a rail transit environment. A list of all adhesives to be used, including location, technical data & specification sheets, and flammability properties, shall be submitted for approval. Adhesives used in less than eight (8) ounces may not require flammability data, subject to the Authority's approval.

[CDR 025]

Joining of components by adhesives shall be completed within the maximum working times as follows; the application, and aligning of bonded components shall be completed within 70% of the adhesives maximum working time, considering application conditions. When two-part compounds are being used, only the amount of adhesive that can be used within 70% of the maximum recommended pot life shall be mixed.

Adhesives that use atmospheric or humidity cure shall be installed such that the air circulation to fully cure the adhesive is possible.

Adhesive selection and bonded joint design shall consider MIL-HDBK-691B.

1.11.4 Sealants & Caulking

The use of caulking and sealing compounds shall be minimized.

Caulking and sealing compounds shall be applied in accordance with the manufacturer's instructions and recommendations, shall be non-staining, and shall be supplied in colors closely matching those of adjacent materials and surfaces. Caulking used in exterior applications shall be UV light resistant. If butyl-type is used, it shall be extruded polyisobutylene sealer compound of 100% solids.

Caulking primers shall be quick-drying, colorless, non-staining sealers of a type and consistency recommended by manufacturers of caulking materials for the particular surface involved.

Packing (backstop) shall be non-staining, resilient material, such as fiberglass roving neoprene, butyl, closed-cell foams, or other compressible materials compatible with the caulking compound used. Joints, spaces, and junctures to be packed and caulked or sealed shall be completely cleaned of dirt, dust, oil, and other foreign materials that

would adversely affect caulking quality. Suitable primer shall be used to achieve full adhesive bond.

Surfaces shall be thoroughly dry before caulking compounds are applied. Caulking compound application shall be compatible with prior, or subsequent paint application. When so stipulated by the sealant manufacturer, paint and other protective coatings shall be removed from surfaces to be caulked prior to priming and application of sealants.

Compounds shall be applied with pneumatic guns. Where the use of a caulking gun is impracticable, suitable hand tools shall be used.

Unless otherwise indicated, the entire perimeter of each opening shall be caulked.

The finish of caulking joints on flush surfaces and in internal corners shall be neatly pointed; excess material shall be removed; and, where exposed, the caulking shall be free of wrinkles and uniformly smooth.

Application of polysulfide or silicone compounds shall be in accordance with the manufacturer's instructions and recommendations.

Compounds shall not be used when they become too gelled to be discharged in a continuous flow or exceed their stated shelf life, and they shall not be modified by addition of liquids, solids, or powders. Compounds shall be installed within the manufacturer's defined temperature range.

Installation and working of compounds shall be completed within the maximum working times as follows: The application and working of caulking material shall be completed within 70% of the minimum "skin" time, considering application conditions. When two-part compounds are being used, only the amount of caulking that can be installed within 70% of the maximum recommended pot life shall be mixed.

Adjoining surfaces, finishes, and fixtures shall be carefully protected throughout caulking operations. Stains, marks, or damage as a result of caulking and sealing work shall be removed.

1.12 Insulation

Insulating materials shall be fire-retardant, non-hygroscopic, resistant to fungus, and provided with a vapor barrier as required to prevent the entry of moisture, oil, gases, and dust.

The materials shall not absorb fluids and gases and shall possess the required properties

to meet the noise and vibration requirements of this specification.

The method of insulation retention in the carshell, for all insulating materials, shall be subject to Authority approval.

The Contractor shall submit for approval data on thermal and acoustic insulation materials and application processes.

[CDR 026]

1.12.1 Acoustic Insulation

Sound damping material used in the fabrication of the vehicle shall be resistant to diluted acids, greases, fuel oils, aliphatic oils, and vermin. The material must be resistant to fungus and must not support combustion. The material shall not be affected by sunlight or ozone, and shall not become brittle with age. The application shall be in accordance with the manufacturer's recommendations.

1.12.2 Thermal Insulation

Thermal insulation materials shall be transportation grade of the rigid, non-rigid, or spray-on type. Insulation shall be installed with a vapor barrier to preclude moisture accumulation.

The type of thermal insulation to be used shall not be susceptible to mold or rot and shall not absorb water. Metals, which are attached to the insulation, shall be corrosion resistant, and not settle under vehicle vibration. The vehicle thermal insulation shall not have an odor or be capable of absorbing odors, and shall not sustain vermin. Urethane foam insulation is expressly prohibited.

Thermal insulation material shall have the same thermal conductivity as the originally used material.

1.13 Fabrics & Upholstery

Upholstery fabrics for vehicle seats shall be approved transportation-grade fabrics with backing. Fabric shall be able to be cleaned by at least three widely available commercial industrial cleaning agents that are known to be chemically compatible.

1.13.1 Woven Fabric

Woven upholstery fiber, where used, shall be worsted spun. Fiber content shall be 90%

wool and 10% nylon. Fabric weight exclusive of backing shall be not less than 12.2 oz/yd2 [0.41 kg/m^2] . Maximum fabric shrinkage shall be 2%.

Woven Seat Upholstery shall meet the following standard test criteria:

Table 19-8

Physical Property	Test Method	Requirement
Weight	ASTM D 3776, Option B	12.5 oz/sq. yard
Fabric Construction	ASTM D3775	43 PPI
Tensile Strength	ASTM D 5034	100 lbs. Warp 100 lbs. Fill
Tearing Strength (Tongue)	ASTM D 2262, B3, Sec 7.2	Warp - 20 lbs Fill - 15 lbs.
Abrasion Resistance	ASTM D 3884, Taber 500g, CS 10 Wheel	500 Cycles Minimum, No breaks
Crocking	ASTM D 3597, Sec 7.9, (AATCC Method 16, Option E)	4.0 Dry 4.0 Wet
Pilling Resistance	ASTM D 3512	Pass, level 4 (slight pilling)
Shrink Resistance	AATCC 99-2000	2% maximum
Light Fastness	ASTM D 3597, Sec 7.10, 40 hrs	4@40 Hours
Seam Strength (sewing)	ASTM D 1683, Sec 11.1	50 lbs.
Yarn Slippage (sewing)	ASTM D 4034	Warp - 50 lbs Fill - 50 lbs.

1.14 Electrical

1.14.1 Wiring General Requirements

Wire sizes, insulation requirements, materials, shielding methods, and identification of

wire and cable used for primary, auxiliary, control, and communications applications shall be based on the current carrying capacity, voltage drop, mechanical strength, temperature, and flexibility requirements of AAR, ASTM, ICEA, NFPA, MIL, or NFPA 70 specifications. All wire, cable, and bus bars shall be copper. Copper bar contact surfaces shall be silver plated.

The minimum insulation thickness for all wiring not contained in enclosures shall be 0.017". Wiring within enclosures shall be of a minimum insulation thickness of 0.013".

All wire and cable insulation shall meet the flame and smoke test requirements of Section 1.17, Flammability, Smoke Emission & Toxicity, and shall be substantially free of halogens. The wire and cable selected shall be rated by the manufacturer to last the life of the vehicle.

The Authority shall approve all electrical wire and cable used in the vehicle. The Contractor shall submit samples and specifications of each size and type of wire and cable proposed for use in the vehicle for Authority approval.

[CDR 027]

Flexible, insulated, stranded copper wire shall be used in all ground strap applications. The termination end of the insulation shall be sealed against water ingress into the jacket.

All conductors of multi-conductor cables shall be terminated.

1.14.1.1 Conductors

Maximum current capacities shall conform to National Electrical Code NFPA 70.

Except as otherwise specified, conductors shall be of soft, annealed, tinned copper stranded in accordance with ASTM B33.

Stranding and conductor construction for all wires and cables No. 18 AWG and larger shall comply with of NEMA WC 70, NEMA WC 71, and AAR S-501, as is appropriate for the application. Stranding shall be per ASTM B174; Class I or equivalent - 10 to 7 AWG, and Class K or equivalent - 18 to 12 AWG.

Stranding and conductor construction for wires and cables No. 20 and No. 22 AWG shall be of 19-strand construction as appropriate for the usage requirements.

1.14.1.2 Wire & Cable Insulation

Each conductor shall be separately covered with insulation. Flat cables are prohibited, except for specific data/communications applications where other arrangements are impractical.

Wire and cable insulation used for carbody wiring shall be flexible, crosslinked polyolefin or ETFE (Tefzel). Removed wires and cables shall be replaced in kind. Wire and cable shall comply with the electrical and physical requirements of NEMA WC 70, NEMA WC 71, and AAR S-501.

Wires within enclosed equipment or suitably protected locations shall comply with MIL-W-81044, or as otherwise approved.

Wire and cable insulation shall be of heat and moisture proof material suitable for a continuous temperature rating of 167°F (75°C) minimum in dry and wet locations. For high-temperature applications, such as connecting to heaters and resistors, the insulation shall be suitable for a maximum conductor temperature of 230°F (110°C).

Asbestos and urethane based insulations or jacket materials shall not be used. PVC based insulation may be used with Authority approval when replacing existing wire or cable of that type.

Outer jacket material of multi-conductor cable shall be the same as that used to insulate individual conductors, unless physical considerations indicate a different material with superior characteristics.

Shielding shall be used over multi-conductor cable for safety-critical circuits. Shielding material shall be woven wire providing not less than 60% coverage and shall be soft, annealed, tinned copper of an area equal to or greater than the largest conductor. Shields shall be grounded at only one end using specifically designed terminal blocks. The non-grounded end of each shield shall be cleanly dressed to prevent shorts or unintended ground contact.

Non-conducting separators and fillers may be applied between conductor and insulation on conductor sizes greater than No. 5 AWG.

Leakage between primary wiring and vehicle body shall be measured in accordance with IEEE 11. The resistance shall be at least 10 MOhms when measured with 1,000-volt megOhmeter.

Hi-Pot shall be accomplished on all primary power wiring at 2,500 VAC for 1 minute per IEEE 11.

1.14.1.3 High-Temperature Wire & Cable

Insulation for all wires in high-temperature applications, including but not limited to those connecting with heaters, resistors, or lights shall conform to the following:

- For wire sizes No. 16 AWG and larger, the insulation shall be silicone rubber in accordance with AAR S-503, 110°C irradiated cross-linked polyolefin, or abrasion-resistant extruded ETFE Teflon meeting MIL-W-22759/6B
- For wire sizes No. 18 AWG and smaller, the insulation shall be abrasion-resistant extruded ETFE Teflon meeting MIL-W-22759/6B. When used for interconnecting pieces of apparatus, this type of wire shall be bundled and shall have a protective covering (conduit, or raceways).

1.14.1.4 Communications Wire & Cable

The communications system manufacturer shall approve all carbody wire and cable applicable to the communications equipment.

All communications wire and cable shall be installed in raceways, conduits or as otherwise approved.

The jacket shall be waterproof and abrasion-resistant, and shall provide insulation resistance greater than 1 MOhm/ft between shield and water.

1.14.1.5 Application & Installation

All wiring shall be performed and directed by experienced personnel using appropriate tools for stripping insulation, cutting, soldering, and attaching mechanical or hydraulic crimp-type terminals with correct dies.

Bus bars shall be connected using appropriately sized steel hardware with flat and lock washers.

All car wiring connected to a given piece of electrical apparatus shall be insulated for the highest voltage supplied to that apparatus. Wires operating with potential differences of 50 volts or more shall not be cabled or routed together. Signaling, Low-Voltage Direct Current (LVDC), Alternating Current (AC), and High-Voltage Direct Current (HVDC) wiring shall be separated.

Wiring for any communications system equipment shall be done in an approved manner to conform to the requirements established by the supplier of that equipment.

All circuits shall be adequately protected and the car body and other structural

components shall not be used for the return. All circuits and branches must be separable by a switch or terminal board to isolate their grounds when trouble-shooting is required.

Wiring shall be fabricated into standard harnesses, and installed in prefabricated groupings, and standardized locations in the vehicles.

Car wiring shall comply with NEC Code, Chapter 3 (NFPA 70), and with the AAR Manual of Standards, Section F, S-538, Wiring Practice, and Rolling Stock Standard, except where otherwise specified.

Circuit protection shall comply with NEC Code, Chapter 2.

Electrical circuits and associated cabling shall be designed with clearance and creepage distance between voltage potentials and carbody ground in accordance with the environmental conditions to which the circuits and cabling will be subjected, and in accordance with NFPA 130, Chapter 4 or equivalent IEC standards.

Electric apparatus shall be housed in sealed enclosures to remain clean and dry. Cooling air shall be filtered to remove all conductive and non-conductive dust.

The layout of wiring shall be designed in advance of its installation and in cooperation with those furnishing the related equipment.

1.14.1.6 Undercar and Roof Wiring Installation

All wiring shall be run in metal raceways and wire ducts.

Wire and cable shall be securely anchored, in a manner approved by the Authority, in the ducts to prevent chafing from relative motion.

Minimum wire size for under car wiring shall be 12 AWG for power circuits and 16 AWG for control circuits. Within equipment enclosures, minimum wire size shall be 22 AWG. Other wire sizes may be proposed by The Contractor but are subject to Authority approval on a case by case basis.

Where physical strength is required, No. 6 AWG or larger wires may be used and supported in place without any type of enclosure by using molded fiberglass reinforced plastic cable support blocks. This method is also acceptable in protected areas subject to damage or vandalism.

The wire ducts and conduits shall be of waterproof construction. Wire duct and conduit entries and exits shall be effectively sealed against water entry using methods or devices subject to Authority approval.

Wires or cables shall not pass over or through the battery compartment, or over

propulsion resistors.

Floor wiring shall be run in conduits or ducts and may be run through partitions, but only if suitable bushings\grommets are provided at such points of passage.

Sufficient slack and wire length shall be provided to prevent breaking or pulling out of bushings or terminals, and to allow for a serviceability loop long enough for three re-terminations.

Drip loops shall be provided where appropriate.

1.14.2 Power Cables

HVDC power cables (with the exception of cables passing through or above the floor) that are No. 6 or larger that are not supported in cables trays or conduit, shall be cleated in place.

The cleats, as specified in Section 1.14.5, shall be positioned at intervals no greater than 18", and adequate clearance shall be maintained between cables and any structural members, components, or items of equipment.

Where mechanical protection is required, short lengths of conduit complying with Section 1.14.4 may be employed. For AC circuits all conductors shall be routed together.

1.14.3 Cable Connectors

All cable connectors shall be of watertight design, unless enclosed in interior watertight cabinets and approved by the Authority, with removable / replaceable crimp contacts of the correct size for the wire being terminated.

Cable connectors shall be equipped with sealing gaskets. Extension bodies shall be used if necessary to ensure that there is sufficient room to terminate the cable wires within the connector body.

The cable jacket shall extend within the body, shall be held by a clamp, and shall have a gasket seal at the entrance.

Unused connector pin positions shall be sealed with either connector contacts or plastic sealing plugs designed for that purpose.

Adjacent connectors shall either use different inserts or different insert orientations to prevent erroneous connections.

Connectors installed in exterior locations shall comply with MIL-DTL-5015. All other connectors shall comply with an equivalent standard, as approved by the Authority.

1.14.3.1 Terminals

Control wire terminations and connections throughout the vehicle shall be with insulated ring tongue connectors of the compression (crimp) type.

Ring lug type terminals shall be AMP AMPOWER for HVDC applications, PIDG for wire sizes 10 AWG or smaller and Solistrand for wire sizes 10 AWG or larger, or Authority approved equal.

Quick-disconnect (fast-on) terminals with locking features may be used, subject to approval, provided that the type of fast-on has demonstrated a satisfactory service in a similar fashion. Materials such as phosphor bronze shall be shown to be suitable for repeated use.

Terminals shall not utilize PVC insulation.

Terminals shall be attached to the wiring with the crimping tools and dies recommended by the connector manufacturer.

The terminal used shall be of the type that securely grips and holds the insulation of No. 10 AWG wire or smaller. The crimp terminal shall be rated to match the wire conductor diameter and the insulation diameter.

Conductors that will be subjected to motion shall utilize the proper strain relief mechanism recommended by the wire manufacturer.

The Contractor shall emulate the numbering system, presently employed on the vehicles.

1.14.4 Conduit and Raceway Requirements

All electrical conduits and wire ways shall be free of burrs, sharp edges, and square corners. Conduit welded into the carbody shall not have any burn-through of weld, or any other penetration into the interior of the conduit. The ends of the conduits and wireways shall be suitably rounded to prevent edge contact with the wire. Conduit radius shall be sufficiently large to allow easy pulling of the wire and meet the minimum bending radius of the wire/cable.

Conduit fittings shall be “Form 7”.

Wires and cables installed in flexing applications shall be housed in abrasion resistant, flexible conduit or sheathing designed for the application, and installed such that there is no pinching, stretching, or kinking under all ranges of motion.

The Contractor shall ensure that wireways, conduits, end threads, and piping, are

suitably protected from corrosion. The methods and procedures employed for corrosion protection shall be subject to Authority approval.

All car wiring shall be housed in metal raceways. Open metal raceways and their elbows, couplings, nipples, bushings, locknuts, universal joints, expansion joints, and other conduit fittings shall be so designed that the sections can be mechanically and electrically coupled, while the wires are protected from abrasion.

High voltage wiring, (i.e., wiring in excess of 120 volts) shall not be run in the same cable ducts, conduits, or raceways as low voltage wiring.

All conduits shall be arranged to prevent moisture traps and shall drain toward control boxes, and shall be supported to the carbody at least every 24".

Wires in conduits, ducts, and raceways shall be free of kinks, insulation abrasions, and insulation skinning.

If a conduit is designed to come through the flooring of the vehicle and into equipment boxes located at the passenger compartment level, the conduit must extend two (2) in above floor level to prevent water or cleaning chemicals from draining onto the below-floor cables.

1.14.5 Cleating

Split block cleats of glass fiber reinforced molded plastic or an approved equivalent shall cleat all cable and wiring not installed in conduits, on cable racks or raceways.

The holes in the cleat shall be sized for the individual wires and cables. Hole edges shall be radiused to prevent square edge contact with cable insulation.

Each cleat shall have a stiffener on the side away from the mounting bracket that will act to spread the bolt clamping force over the entire length of the cleat.

Bolts shall have lock nuts of approved design.

Cable and wiring, other than HVDC, using cleating shall be supported to the carbody at least every 18".

1.14.6 Equipment Enclosures & Junction Boxes & Fittings

Boxes, covers, and fittings of ferrous metal shall be galvanized inside and outside after fabrication. All box covers shall be marked with the vehicle number, all like covers shall be interchangeable. The box covers shall be held in place with latches or blunt end screws. Self tapping screws shall not be used for box covers.

Screws and other hardware shall be made of stainless steel.

All undercar and roof-mounted junction and pull boxes shall be NEMA "4X" enclosures, and shall protect any enclosed equipment and connected conduits from water seepage.

The interiors of all metallic electrical equipment enclosures and junction boxes shall be protected with an electrically insulating white epoxy paint.

1.14.7 Wire Identification & Terminal Markings

Wire numbers shall be assigned to all electrical conductors, whether individual wires or cables, within the entire car.

All wires and cable shall be marked within 12" [305 mm] of the end of the wire . The methodology and wire marking system employed shall be approved by the AuthorityF.

Wires shall be identified according to circuit function, wire number, wire segment, and gauge. Wire identification shall be subject to approval by the Authority.

[CDR 028

1.14.8 Splicing and Taping

Splicing and taping shall not be allowed unless approved by the Authority.

1.14.9 Circuit Protection

Handles shall indicate ON, OFF, and TRIPPED positions. Circuit breakers shall be molded-case type, single- or multi-pole, with frame size suitable for continuous current and interrupting duty. The Contractor shall propose a lockout/tagout system for the Authoritys approval.

Each pole shall be equipped with a trip mechanism consisting of an inverse time element for overload protection and an instantaneous magnetic element for short circuit protection.

Each pole shall be equipped with adequate means of arc extinction to prevent flashover.

Multi-pole breakers shall operate contacts simultaneously.

Breaker current rating shall be clearly visible after installation and shall comply with NEMA AB1, ANSI C37.13, C37.14, or C37.16.

Continuous current rating shall be selected in accordance with NFPA 70 for load and type of service indicated.

Electrically controlled breakers shall be equipped for operation from the Low-Voltage Power Supply (LVPS).

Circuit breakers/fuses shall be properly coordinated with all other protective devices.

Other than High Speed Circuit Breakers (HSCBs) used for HVDC circuits, circuit breakers shall not be used for protection on HVDC circuits.

Fuses shall not be used except for fuses within electronic assemblies, high voltage circuit protection, and special applications with Authority approval.

1.14.10 Grounding

Ground bonding connections shall be made through copper pads, tinned, and silver soldered to the carbody.

The copper ground pads shall be tinned or silver electroplated after attachment. .

Low voltage and high voltage circuits shall not be grounded to the same grounding pad, unless such grounding is permitted by this specification.

All ground pads shall be visible and accessible for inspection and troubleshooting. The ground connections shall be attached by an approved bolt, washer, and nut designed for the purpose as specified in Section 1.7.2.6.

Resiliently-mounted equipment shall be grounded with flexible strap-type grounding leads bolted between a car body grounding pad and the equipment's grounding pad. Strap flexibility and length shall be sufficient to prevent failure from fatigue. Fixed equipment maybe grounded by flexible straps or properly terminated wire of the same type used for car wiring.

The ground strap termination method shall form a gas-tight, uniformly distributed connection with the conductive surface. Current density shall not exceed bonding requirements below.

All grounding and bonding jumpers and straps shall be sized to handle fault current and lightning discharge current, for which the voltage drop shall not exceed 50 volts?. The bonding method employed shall not produce a DC resistance in excess of 0.0025 Ohms, or more than 0.025 Ohms at 150 kilohertz for any applied AC voltage.

All equipment enclosure and shock-mounted equipment ground straps shall be replaced in kind.

In no case shall the size of a ground cable or shunt be less than No. 10 AWG.

The Contractor shall ensure that all metal parts inside and outside the vehicle that could be touched by passengers, operating personnel, or maintenance personnel, including equipment boxes, panels, and test receptacles in the passenger or operator areas, shall never exceed carbody potential.

1.14.11 Electrical Components

Electrical components, which are singularly replaceable, shall be connected to car wiring through individual, removable connections, or "pigtails" with connectors. Replaceable components shall not be connected to car wiring using soldered connections.

1.14.12 Relays and Contactors

Contactors and relays shall meet or exceed IEC 60077.

Low-current relays (less than 10 Amp per pole) shall have silver-alloy contacts.

Very low current relays (1 Amp and less) shall have gold-plated, silver-alloy contacts.

Relays and contactors that have not been proven in rail service shall comply with MIL-PRF-6106.

Relays shall be capable of at least one million (1,000,000) electrical operations at rated contact capacity with the exception of those operating on the order of one thousand (1000) times per day being capable of at least ten million (10,000,000) electrical operations at rated capacity.

Plug-in relays shall be secured in their sockets by mechanical restraint.

Relay and contactor coils shall be suppressed to mitigate transient voltage spikes, with the suppressing network mounted as close to the coil as possible.

Relays and contactors, except low-power miniature relays mounted on printed-circuit boards, shall incorporate means of visually determining whether contacts are picked up or dropped out.

Relays used in safety-critical circuits with single point failures shall comply with the AAR Signal Manual, Volume 2, Section 6, unless otherwise approved.

Contactors used to interrupt HVDC circuits shall be equipped with blowout coils or other means of arc suppression in accordance with the OEM’s recommendation.

1.14.13 Pushbutton Switches

Switches shall be heavy-duty, with electrical characteristics, ratings, and accessories as required for circuit application.

Pushbutton (including illuminated) switches shall have silver-plated or silver-alloy contacts.

Indicators and pushbutton switches shall have insulation resistance of at least 1 MOhm to case at 500 VDC as measured by a megger. Re-lamping of indicators shall be from front.

Contacts shall have maximum resistance of 0.050 Ohm at 3 VDC and 10 mA load. Minimum open contact resistance shall be 50 MOhm.

Contact shall be rated for inductive loads. The contacts shall normally operate at not more than 20% of the manufacturer's inductive rating for twenty-five thousand (25,000) cycles of operation at 25^{o}C. The electrical contact material shall be plated with silver or silver with a gold flash or gold plate, and be normally a break-before-make type.

1.14.14 Inductors

Power inductors shall have vacuum-impregnated windings and be rated to withstand at least twice the maximum peak-to-peak voltage expected in normal operation.

1.14.15 Transformers

Transformers shall have vacuum-impregnated windings and have a minimum inter-winding breakdown voltage of 1,500 VDC. Exceptions to this requirement may be granted on a case-by-case basis, upon approval by the Authority.

1.14.16 Resistors

Resistors other than power/braking resistors shall be derated 50% minimum.

1.14.17 Capacitors

Capacitors shall be rated for transients of at least twice the maximum peak voltage expected in normal operation and be applied at continuous voltages not greater than 80% of rated working voltages. Exceptions to this requirement may be granted on a case-by-case basis, upon approval by the Authority.

1.14.18 Motor Starters

Motor starters, if used, shall be rated for continuous duty and, shall be equipped with magnetic holding coils.

Starters shall be equipped with sufficient auxiliary contacts to comply with requirements for annunciator circuits, as indicated.

Thermal overload protection shall be provided.

Three-phase starters shall be three-pole.

1.14.19 Electronic Components

Electronic components shall be free of storage and handling damage. Where possible, components shall be clearly and permanently labeled with values or type identification.

Semiconductor devices shall be available from two (2) or more qualified manufacturers. Exceptions to this requirement may be granted on a case-by-case basis, upon approval by the Authority.

Carbon resistors shall not be used on Printed Circuit Boards (PCB).

Components as applied in their circuits shall be derated by at least 25% from manufacturer's ratings.

For power semiconductors, derating of current shall be such that manufacturer's maximum junction temperature is not exceeded with 25% increase in semiconductor current above that required for maximum performance specified in Section 2.

1.14.20 Printed Circuit Boards

PCBs shall be of glass epoxy construction, complying with NEMA LI1, grade FR-4, or equivalent standard such as IEC 249.

PCBs shall be uniformly coated.

Conductor materials shall be determined on the basis of current carrying capacity and in accordance with IEC 326-3.

Edge connectors and boards shall be keyed to prevent insertion of any board in a wrong position, and mounted for ease of board removal and replacement.

To the greatest extent practicable, component labeling shall be provided on PCBs.

1.14.21 Semiconductor/Integrated Circuits Requirements

Suppression devices shall be provided to protect the devices and limit the circuit voltage.

Non-Joint Electron Device Engineering Council (JEDEC) registered devices which carry more than 100 Amps may be used with prior approval, based on submission of complete procurement specifications defining each such device and evidence of availability from two (2) or more manufacturers.

All semiconductor/integrated circuits shall be rated to properly perform in the range -40^{o} to +85^{o}C [-40^{o} to +185 ^{o}F].

Transistors and other solid-state power devices operated from nominal battery supply shall have minimum breakdown ratings of four (4) times the maximum circuit voltage. Suppression devices shall be provided to protect the devices and limit the circuit voltage.

All integrated circuits shall be tested for defects. The Contractor shall submit for approval testing methods based on a minimum of a 48-hour burn-in for the completed assembly.

[CDR 029]

1.15 Microprocessor-Based System Requirements

Microprocessor-based components, assemblies, and power supplies shall be provided with voltage/current regulation and protection to ensure proper operation.

All interfacing wiring shall be protected against interference from other on-car or wayside electrical radiation.

The microprocessor shall be of a family shown to be suitable for the rugged environmental conditions encountered in rail applications, and shall be supported by software development language and diagnostic programs, which are acceptable to the Authority.

The microprocessor assembly shall be housed in an enclosure, which shields the microprocessor assembly and the surrounding circuits from Electromagnetic Interference (EMI) and radiation.

The microprocessor shall have external buffers provided, and shall be protected from external voltage and current transients and EMI.

1.16 Software Requirements

Where the software is essentially a modification of an existing product to meet the Authorities' requirements, the design process, and documentation, shall be submitted for review and approval by the Authority.

[CDR 030]

For newly developed software, The Contractor and/or supplier shall submit a Software Quality Assurance Plan for approval complying with IEEE 730 or equivalent, and containing, as a minimum, the following documentation requirements:

[CDR 031]

a. Software Requirements Specification

b. Software Design Description

c. Software Verification and Validation Plan

d. Software Verification and Validation Report

e. User Documentation

The Software Design Description, in (b) above, shall comply with IEEE 1016 or equivalent.

The requirements of this section shall be presented to the Authority at the Preliminary Design Reviews. The Authority shall be properly notified of meetings and reviews scheduled to determine progress with respect to the software requirements and the software design description by The Contractor.

1.17 Flammability, Smoke Emission & Toxicity

New materials used in the vehicle shall comply with the flammability, smoke emission, toxic gas, and fire retardation requirements specified herein.

Materials used in the vehicles shall be zero (0) halogen in addition to meeting the low-smoke requirements specified below.

As a minimum, all materials used in the construction of the vehicle shall meet the requirements of the 49 CFR Appendix B to Part 238-Test Methods and Performance Criteria for the Flammability and Smoke Emission Characteristics of Materials Used in Passenger Cars and Locomotive Cabs. Unless specified below, all materials and construction shall meet the requirements of NFPA 130, Table 5-2.4, shall be enforced.

Should a conflict exist between the NFPA and Federal requirements and requirements

listed elsewhere in these provisions, the more restrictive shall govern.

The Contractor shall furnish a list of materials (flammability matrix) used in the vehicles showing location of material, weight (density and total weight), heat value per pound and per vehicle, flame spread, flashpoint, smoke generation, and toxicity. The Contractor shall submit laboratory test results for each test, including a technical data sheet, for approval.

[CDR 032]

Test report documentation shall specifically identify the tested material by the same description that appears on the technical data sheet and other related references. This documentation must be directly traceable to the applicable car builder drawings without ambiguity.

Copies of prior test results showing that proposed materials have complied with the specified standards and tests may be submitted for approval. Assurance may be required that the material presently being considered for use is the same composition as that previously tested.

Table 19-9

Function of Material (see comments)	Test Procedure	Performance Criteria
All vehicle materials & components except as otherwise noted. (Wall Panels, Ceiling Panels, Partition Panels, Windscreens, Fiberglass, Plastics, Diaphragms, Non-sealing Elastomers, etc.) (1, 2, 9, 12)	ASTM E 162 ASTM E 662	I_s ☐ 35 D_s (1.5) ☐ 100, D_s (4.0) ☐ 200 (to exclude polyester resin FRP, use the following: D_s (1.5) ☐ 100, D_s (4.0) ☐ 165)
HVAC Ducting (1, 2)	ASTM E 162 ASTM E 662	I_s ☐ 35 D_s (4.0) ☐ 100
Lighting Diffusers / Plastic Glazing (2, 14)	ASTM E 162 ASTM E 662	I_s ☐ 100 D_s (1.5) ☐ 100, D_s (4.0) ☐ 200
Thermal and Acoustical Insulation (1, 2)	ASTM E 162 ASTM E 662	I_s ☐ 25 D_s (4.0) ☐ 100
Flexible Cellular Foams (1, 2, 4, 6)	ASTM D 3675 ASTM E 662	I_s ☐ 25 D_s (1.5) ☐ 100, D_s (4.0) ☐ 175

Function of Material (see comments)	Test Procedure	Performance Criteria
Elastomers – Lock strip gaskets (1, 2, 10, 11)	ASTM C 542 ASTM E 662	Pass criteria in table 1 D_s (1.5) ☐ 100, D_s (4.0) ☐ 200
Elastomers – Other gaskets or seals (1, 2, 10, 11)	ASTM C 1166 ASTM E 662	100mm (4.0in), maximum flame propagation (15) D_s (1.5) ☐ 100, D_s (4.0) ☐ 200
Structural – Floor, Roof (16, 17, 18)	ASTM E 119	Pass (30 Minutes minimum endurance at AW3 loading)
Floor Covering (12, 13)	ASTM E 648 ASTM E 662	CRF ☐ 0.5 W/cm^2 D_s (1.5) ☐ 100, D_s (4.0) ☐ 200
Seat Cushion, Mattresses (1, 2, 3, 4, 5, 6, 7, 8)	ASTM D 3675 ASTM E 662	I_s ☐ 25 D_s (1.5) ☐ 100, D_s (4.0) ☐ 175
Seat Frame, Seat Shroud (1, 2)	ASTM E 162 ASTM E 662	I_s ☐ 35 D_s (1.5) ☐ 100, D_s (4.0) ☐ 200
Upholstery (1, 2, 3, 6, 7, 8)	14 CFR (FAR) 25.853 (Appendix F, vertical, textiles) ASTM E 662	Flame Time ☐ 10 sec Burn Length ☐ 150mm, (6"). D_s (4.0) ☐ 200
Wire Insulation (1, 2, 19)	IEEE Std 383 - Flammability ASTM E 662	Pass D_s (4.0) ☐ 50

I_s = Ignition time in seconds for a flammable material usually done with ASTM E 162 test or similar,

D_s = Smoke Density in Seconds usually done with ASTM E 662 test

CRF= Critical Radiant Flux, also a flammability test like the Ignition Time usually measured in Watts/sq-cm, and usually tested by one of the ASTM radiation panel tests

W = Watts

$q\ddot{y}$ = Heat flux in the y direction (i.e., out from surface of sample, usually laying down,

versus vertical or angled; similar to CRF)

Numbered comments are based upon NFPA 130, and 49 CFR Appendix B to Part 238. These comments have been either quoted, combined from both, or adapted/edited to passenger transit applications.

1) Materials tested for surface flammability shall not exhibit any flaming running or dripping unless an appropriate fire hazard analysis is conducted and approved by the Authority.

2) The ASTM E 662-97 maximum test limits for smoke emission (specific optical density) shall be measured in both the flaming or non-flaming mode, values shall be provided for both cases.

3) Testing of a complete seat assembly (including cushions, fabric layers, upholstery) according to ASTM E 1537 using the pass/fail criteria of California Technical Bulletin 133, and testing of a complete mattress assembly (including foam and ticking) according to ASTM E 1590 using the pass/fail criteria of California Technical Bulletin 129 shall be permitted in lieu of the test methods prescribed herein, provided the assembly component units remain unchanged or new (replacement) assembly components possess equivalent fire performance properties to the original components tested. Testing shall be at 50 kW/m2 applied heat flux with a retainer frame. A fire hazard analysis must also be conducted that considers the operating environment within which the seat or mattress assembly will be used in relation to the risk of vandalism, puncture, cutting, or other acts which may expose the individual components of the assemblies to an ignition source. The requirements of Notes 5, 6, 7, and 8 shall be met.

4) Testing is performed without upholstery.

5) The surface flammability and smoke emission characteristics shall be demonstrated to be permanent after dynamic testing according to ASTM D 3574, Test I 2 (Dynamic Fatigue Test by the Roller Shear at Constant Force) or Test I 3 (Dynamic Fatigue Test by Constant Force Pounding) both using Procedure B, except that the test samples shall be a minimum of 6” (154 mm) by 18” (457 mm) by the thickness of the material in its end use configuration, or multiples thereof. If Test I 3 is used, the size of the indentor described in paragraph 96.2 shall be modified to accommodate the specified test specimen.

6) The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by washing, if appropriate, according to FED-STD-191a Textile Test Method 5830.

7) The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by dry-cleaning, if appropriate, according to ASTM D 2724-87.

8) Materials that cannot be washed or dry-cleaned shall be so labeled and shall meet the applicable performance criteria after being cleaned as recommended by the manufacturer.

9) As a minimum, all combustible materials used anywhere in the vehicle (except as noted in 10) are required to be tested including interior, cab components as well as exterior components. Combustible signage shall not be required to meet flame spread or smoke emission requirements if (a) the actual thickness of the signage is no greater than 0.060” [1.5 mm]; (b) the aggregate area of combustible signage does not exceed 10% of the wall area of the car,

including windows; and (c) no single sign is larger than 0.47 m^2 (5.0 ft^2). Items that can not be made compliant due to other dominating engineering requirements may not be required to meet the flammability or smoke emission performance criteria specified, but still must be tested to establish the relative risk and evaluated by the Authority.

10) Materials used to fabricate miscellaneous, discontinuous small parts (such as knobs, rollers, fasteners, clips, grommets, and small electrical parts) that will not contribute materially to fire growth in end use configuration are exempt from flammability and smoke emission performance requirements, provided that the surface area of any individual small part is less than 16 $in.^2$ (100 cm^2) in end use configuration and an appropriate fire hazard analysis is conducted which addresses the location and quantity of the materials used, and the vulnerability of the materials to ignition and contribution to flame spread.

11) If the surface area of any individual small part is less than 16 $in.^2$ (100 cm^2) in end use configuration, materials used to fabricate such a part may be tested in accordance with ASTM E 1354 as an alternative to both (a) the ASTM E 162 flammability test procedure, or the appropriate flammability test procedure otherwise specified in the table, and (b) the ASTM E 662 smoke generation test procedure. Testing shall be at 50 kW/m applied heat flux with a retainer frame. Materials tested in accordance with ASTM E 1354 shall meet the following performance criteria: average heat release rate (qÿ // 180) less than or equal to 100 kW/m2, and average specific extinction area (sf) less than or equal to 500 m^2/kg over the same 180-second period.

12) Carpeting used as a wall or ceiling covering shall be tested according to ASTM E 162 and ASTM E 662 and meet the respective criteria of I s less than or equal to 35 and D s (1.5) less than or equal to 100 and D s (4.0) less than or equal to 200. Notes 1 and 2 apply.

13) Floor covering shall be tested with padding in accordance with ASTM E 648, if the padding is used in the actual installation.

14) For double window glazing, only the interior glazing is required to meet the requirements specified herein. (The exterior glazing is not required to meet these requirements.)

15) Average flame propagation shall be less than 4” and no specimen shall be completely consumed.

16) Penetrations (ducts, access openings, etc.) shall be designed against acting as passageways for fire and smoke and representative penetrations shall be included as part of test assemblies.

17) A structural flooring assembly separating the interior of a vehicle from its undercarriage shall meet the performance criteria during a nominal test period as determined by the Authority. The nominal test period must be twice the maximum expected time period under normal circumstances for a vehicle to stop completely and safely from its maximum operating speed, plus the time necessary to evacuate all the vehicle's occupants to a safe area. The nominal test period must not be less than 15 minutes. Only one specimen need be tested. A proportional reduction may be made in the dimensions of the specimen provided it serves to truly test the

ability of the structural flooring assembly to perform as a barrier against under-vehicle fires. The fire resistance period required shall be consistent with the safe evacuation of a full load of passengers from the vehicle under worst-case conditions.

18) Testing shall be conducted in accordance with ANSI/IEEE Standard 383-1974, section 2.5, with the additional requirement that circuit integrity shall continue for 5 minutes after the start of the test.

1.18 SUBMITTALS – CDR

The following items shall be submitted to the Authority for review and approval. The applicable specification section is given for reference.

Table 19-10

CDR No.	Title/Description	Section Reference	Due Date
001	Commercial Material; Specifications and Description of Material Composition	1.1	As material is identified
002	Specification Equivalency/Benefit Data for any Substitution to a Cited Standard	1.1	As material is identified
003	Material Safety Data Sheets for All Chemical Materials Used in Vehicle Construction	1.1	With delivery of the last rebuilt vehicle
004	Material Matrix Including Copies of Technical Data & Specification Sheets, Test Reports and Material Certifications	1.1	Initial matrix: 90 calendar days after NTP; thereafter monthly updates
005	Joining and Fastening Data, Standards, and Specifications	1.1	180 calendar days after NTP
006	Elastomer Properties and Specifications	1.5.1	As material is identified
007	Neoprene Foam Physical and Performance Characteristics	1.5.2	As material is identified
008	Certificates for Reinforced Plastic Materials	1.5.3	As material is identified
009	Test Reports to Verify Glazing Material Compliance	1.5.5	15 calendar days after completion of each test
010	Floor Covering Samples	1.5.6	180 days after NTP

CDR No.	Title/Description	Section Reference	Due Date
011	Fastener Material and Usage	1.7.2	180 calendar days after NTP
012	Demonstration of AWS Welding Compliance	1.7.4	10 calendar days before start of any structural welding
013	Welding Specifications, Procedures, and Certifications of Personnel Performing These Operations	1.7.4	10 calendar days before start of any structural welding
014	Procedure Qualifications Record (PQR) for all weld joints to be used or pre-qualified per AWS codes and all Weld Procedure Specifications (WPS)	1.7.4.2	10 calendar days before start of any structural welding
015	Brazing Specifications, Procedures, and Certifications of Personnel Performing These Operations	1.7.5	10 calendar days before start of any brazing
016	Soldering Specifications, Procedures, and Certifications of Personnel Performing These Operations	1.7.6	10 calendar days before start of any soldering
017	Test report for each vehicle, including retest reports if appropriate	1.8	15 calendar days after completion of each test
018	Piping, Tubing, and Pressure Vessel Data	1.8	180 calendar days after NTP
019	Piping Flushing and Cleaning Procedures	1.8.1	180 calendar days after NTP
020	Bearing Data for All Recommended Bearings and Bushings	1.9	210 calendar days after NTP
021	Lubricant Data for All Recommended Bearings and Bushings	1.9	90 calendar days before scheduled delivery of first rebuilt LRV
022	Corrosion-Resistance Procedures/Processes	1.10	90 calendar days after NTP
023	Dissimilar Metal Corrosion Protection Procedures	1.10.1	120 calendar days after NTP

CDR No.	Title/Description	Section Reference	Due Date
024	Data on Paints, Primers, and Application Processes/Procedures	1.11.1	180 calendar days after NTP
025	List and Properties of Adhesives	1.11.3	180 calendar days after NTP
026	Thermal and Acoustical Insulation Data and Application Process	1.12	210 calendar days after NTP
027	Samples, and Specifications, of Each Size and Type of Wire and Cable	1.14.1	180 calendar days after NTP
028	Wire Numbering Plan	1.14.7	90 calendar days after NTP
029	Integrated Circuit Burn-in Test Methods	1.14.21	270 calendar days after NTP
030	Existing Software Design Process and Documentation	1.16	270 calendar days after NTP
031	Software Quality Assurance Plan	1.16	180 calendar days after NTP
032	Combustible Material Matrix, and Supporting Test Results for All Combustible Materials	1.17	Initial list: 180 calendar days after NTP; thereafter updated monthly

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

TECHNICAL SPECIFICATION

EE&QA - 962

Common Work Requirements

ISSUED: **August 11, 2023**

REVISION: **1**

SUBWAY OPERATIONS DIRECTORATE
EQUIPMENT ENGINEERING AND QUALITY ASSURANCE

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1.0 COMMON WORK REQUIREMENTS:

1.1 Non-Destructive Inspection (NDT)

1.1.1 Visual Inspection (VT)

1.1.1.1 The Contractor shall submit a visual inspection procedure as needed prior to beginning manufacturing of the drop axle.

1.1.1.1.1 The Contractor shall establish minimum lighting criteria to use during visual inspection.

1.1.1.1.2 Borescope inspection may be used in lieu of direct visual inspection for inaccessible or difficult-to-access locations.

1.1.1.2 VT inspection acceptance/rejection criteria for wear, damage, deformation, corrosion, burning, plating integrity, or other defects shall be proposed by the Contractor for Authority approval.

1.1.1.2.1 Electrical components shall be inspected for damaged or worn insulation, loose or damaged contacts, scorching, illegible or missing wire markers, or other defects impacting serviceability.

1.1.1.3 VT inspection acceptance/rejection criteria for cracks and weld defects shall be as follows:

1.1.1.3.1 Cast base materials: ASTM E125 Type 1 discontinuities with severity level greater than 1 shall be rejected.

1.1.1.3.2 Fabricated Components - Base Material: Indications with a major axis longer than 1/8” shall be rejected.

1.1.1.3.3 Fabricated Components - Welds: Acceptance criteria per AWS D1.1 or other Authority approved industry standard.

1.1.2 Magnetic Particle Inspection (MT)

1.1.2.1 MT inspections shall be performed in accordance with the latest revision of ASTM E709.

1.1.2.1.1 Half wave-rectified alternating current shall be used, sufficient to detect surface and sub-surface defects.

1.1.2.1.2 Adequate magnetic field strength shall be verified by the use of a “pie gage” (Field Strength Indicator).

1.1.2.1.3 The affected area of the drop axle shall be demagnetized to not more than 5 gausses upon completion of all magnetic particle testing.

1.1.2.2 MT inspection acceptance/rejection criteria shall be as follows:

1.1.2.2.1 Cast base materials: ASTM E125 Type 1 discontinuities with severity level greater than 1 shall be rejected.

1.1.2.2.2 Fabricated Components - Base Material: Indications with a major axis longer than 1/8” shall be rejected.

1.1.2.2.3 Fabricated Components - Welds: Acceptance criteria per AWS D1.1 or other Authority approved industry standard.

1.1.2.3 The inspector performing the inspection shall be certified, qualified to operate the equipment, perform the MT inspection, and evaluate the results in accordance with ASNT SNT-TC-1A, or Authority Approved Alternate.

1.1.2.4 The Contractor shall submit a written MT inspection procedure with acceptance criteria for Authority approval prior to beginning manufacturing.

1.1.3 **Dye Penetrant Inspection (PT)**

1.1.3.1 PT inspections shall be performed in accordance with the latest revision of ASTM E165.

1.1.3.2 PT inspection acceptance/rejection criteria shall be as follows:

1.1.3.2.1 Fabricated Components - Welds: Acceptance criteria per AWS D1.1 or other Authority approved industry standard.

1.1.3.2.2 Fabricated Components - Base Material: Indications with a major axis longer than 1/8” shall be rejected.

1.1.3.3 The inspector performing the inspection shall be certified to perform the PT inspection and evaluate the results.

1.1.3.4 The Contractor shall submit a written PT inspection procedure with acceptance criteria for Authority approval prior to beginning manufacturing.

1.1.4 **Ultrasonic Inspection (UT)**

1.1.4.1 UT inspections shall be performed in accordance with the latest revision of ASTM A388.

1.1.4.2 UT inspection acceptance/rejection criteria shall be as follows:

1.1.4.3 The inspector performing the inspection shall be certified to perform the UT inspection and evaluate the results.

1.1.4.4 The Contractor shall submit a written UT inspection procedure with acceptance criteria for Authority approval prior to beginning manufacturing.

1.2 **Weld Repairs of Cracks in Fabricated Structures**

1.2.1 Except with written Authority approval, this Section is not applicable for stamped or forged parts; parts fabricated from quench and tempered, thermo-mechanically processed, or precipitation hardened materials; bearing surfaces; press-fit surfaces; or any surface that cannot be brought into full conformance with OEM requirements after welding and grinding.

1.2.2 Weld repair of cracks or defects in fabricated structures that are less than 6 inches in length are within the Contractor's scope of work. Cracks longer than 6 inches shall be considered Hidden Damage and the Contractor shall submit a CAP for Authority review and approval.

1.2.3 Cracked or defective welds shall be repaired using weld preparation matching the OEM weld layout.

1.2.4 Cracks shall be prepared for welding by grinding or gouging. The area surrounding the weld joint preparation shall be free from scale, oil, dirt, and other extraneous matter.

1.2.4.1 If air or carbon arc gouging is used for preparation, a minimum of 1/8 inch of material shall be removed from all gouged surfaces by grinding prior to welding.

1.2.5 If the crack occurs in the base material, the joint preparation shall be as follows:

1.2.5.1 If the crack extends through the base material and the root of the weld is accessible, a "double V" joint preparation shall be used, and the weld shall be performed from both sides. The root of the weld shall be chipped, ground, or scarfed clean, and MT inspected prior to welding from the opposite side.

1.2.5.2 If the crack extends through the base material and the root of the weld is inaccessible, a "single V" joint preparation shall be used, extending completely through the base material, and a backing strip shall be used. The backing strip shall be removed after welding and weld qualifications shall be performed using the same backing material as for repair welds.

Extreme cases where the backing cannot be removed shall be brought to the Authority's attention prior to preparing the crack.

1.2.5.3 If the crack extends only partially through the base material, a "single V" joint preparation shall be used, and the weld shall be performed from one side only.

1.2.6 If the crack occurs in a weld, the weld shall be completely removed for the entire length of the crack. Joint preparation and welding shall be performed matching the OEM weld layout.

1.2.6.1 Reference the applicable equipment Section for OEM weld layouts.

1.2.7 Regardless of the joint preparation used, MT inspection shall be performed prior to welding to verify that the crack has been completely removed.

1.2.8 The structure being welded shall be held securely during welding to prevent distortion.

1.2.9 Welding shall be performed using flux cored arc welding (FCAW), gas metal arc welding (GMAW), shielded metal arc welding (SMAW) or Authority approved welding process.

1.2.9.1 Welding consumables such as electrode, shielding gas, and backing shall be in accordance with AWS D1.1, D1.3, or other Authority approved industry standard for the material(s) being welded. Welding consumables are subject to Authority review.

1.2.9.2 Preheat and inter-pass temperature shall be in accordance with AWS D1.1, D1.3, or other Authority approved industry standard for the material(s) being welded. In no case shall the preheat temperature be less than 4.5°C (40°F) or the inter-pass temperature exceed 288°C (550°F).

1.2.9.3 Stringer beads shall be used for all welds, limiting side-to-side motion to 5 times the electrode diameter.

1.2.9.4 All welding repairs shall be performed by qualified welders using qualified procedures in accordance with AWS D1.1, D1.3, or other Authority approved industry standard. Pre-qualification and use of pre-qualified welds and welding procedures is not acceptable.

1.2.9.5 Where possible, welding shall be performed in the flat position. All other positions require additional weld and welder qualifications. Vertical welding is permitted only in the up direction.

1.2.10 After completing the root weld pass, MT inspection shall be performed to assure that a sound weld has been made. MT inspection shall be performed after each intermediate weld pass to verify soundness of the weld pass.

1.2.10.1 Defects found during MT shall be removed and repaired using an Authority approved procedure.

1.2.11 The root pass and each intermediate weld pass shall be de-slagged or peened with an air driven hammer until cleaned to bare metal.

1.2.12 All welds shall be cooled in still air. Forced cooling of any pass or completed weldment shall not be permitted.

1.2.13 The completed weld shall be finished by grinding, where applicable. MT and VT shall be performed to identify defects such as cracks, lack of fusion, porosity, slag inclusions, or undercut.

1.2.13.1 Defects found shall be removed and repaired using an Authority approved procedure.

1.2.14 As a final operation, the entire weld and ½ inch of the parent material on each side shall be peened.

1.2.15 Wherever MT inspection is required, VT inspection shall also be performed. For non-ferromagnetic materials such as aluminum alloys, copper alloys, or austenitic stainless steel, PT shall be used in place of MT. All NDT inspection shall be performed.

1.2.16 The Contractor shall submit a weld repair procedure for cracks in fabricated structures for Authority approval prior to welding any parts.

1.3 **Weld Repairs of Defects in Castings**

1.3.1 Weld repair of cracks or defects in cast material that are less than 6 inches in length are within the Contractor's scope of work. Cracks longer than 6 inches shall be considered Hidden Damage and the Contractor shall submit a CAP for Authority review and approval.

1.3.2 Defects shall be prepared for welding by grinding or gouging. The area surrounding the weld joint preparation shall be free from scale, oil, dirt, and other extraneous matter.

1.3.2.1 If air or carbon arc gouging is used for preparation, a minimum of 1/8 inch of material shall be removed from all gouged surfaces by grinding prior to welding.

1.3.3 The joint preparation shall be as follows:

1.3.3.1 If the defect extends through the base material and the root of the weld is accessible, a “double V” joint preparation shall be used, and the weld shall be performed from both sides. The root of the weld shall be chipped, ground, or scarfed clean, and MT inspected prior to welding from the opposite side.

1.3.3.2 If the crack extends through the base material and the root of the weld is inaccessible, a “single V” joint preparation shall be used, extending completely through the base material, and a backing strip shall be used. The backing strip shall be removed after welding and weld qualifications shall be performed using the same backing material as for repair welds. Extreme cases where the backing cannot be removed shall be brought to the Authority’s attention prior to preparing the defect.

1.3.3.3 If the defect extends only partially through the base material, a “single V” joint preparation shall be used, and the weld shall be performed from one side only.

1.3.4 Regardless of the joint preparation used, MT inspection shall be performed prior to welding to verify that the defect has been completely removed.

1.3.5 The casting being welded shall be held securely during welding to prevent distortion.

1.3.6 Welding shall be performed using flux cored arc welding (FCAW) or shielded metal arc welding (SMAW) only.

1.3.6.1 Welding consumables such as electrode, shielding gas, and backing shall be appropriate for the material(s) being welded and the resulting weld deposit shall have a tensile strength exceeding the minimum tensile strength of the base material. Welding consumables are subject to Authority review.

1.3.6.2 Preheat and inter-pass temperature shall be appropriate for the material(s) being welded to prevent cracking or embrittlement of the weld or heat affected zone (HAZ). In no case shall the preheat temperature be less than 4.5°C (40°F) or the inter-pass temperature exceed 288°C (550°F).

1.3.6.3 Stringer beads shall be used for all welds, limiting side-to-side motion to 5 times the electrode diameter.

1.3.6.4 All welding repairs shall be performed by qualified welders using qualified procedures in accordance with ASTM A488. Pre-qualification and use of pre-qualified welds and welding procedures is not acceptable.

1.3.6.5 Where possible, welding shall be performed in the flat position. All other positions require additional weld and welder qualifications. Vertical welding is permitted only in the up direction.

1.3.7 After completing the root weld pass, MT inspection shall be performed to assure that a sound weld has been made. MT inspection shall be performed after each intermediate weld pass to verify soundness of the weld pass.

1.3.7.1 Defects found during MT shall be removed and repaired using an Authority approved procedure.

1.3.8 The root pass and each intermediate weld pass shall be de-slagged or peened with an air driven hammer until cleaned to bare metal.

1.3.9 All welds shall be cooled in still air. Forced cooling of any pass or completed weldment shall not be permitted.

1.3.10 The completed weld shall be finished by grinding, where applicable. MT and VT shall be performed to identify defects such as cracks, lack of fusion, porosity, slag inclusions, or undercut.

1.3.10.1 Defects found shall be removed and repaired using an Authority approved procedure.

1.3.11 As a final operation, the entire weld and ½ inch of the parent material on each side shall be peened.

1.3.12 Wherever MT inspection is required, VT inspection shall also be performed. For non-ferromagnetic materials such as aluminum alloys, copper alloys, or austenitic stainless steel, PT shall be used in place of MT. All NDT inspection shall be performed.

1.3.13 The Contractor shall submit a weld repair procedure for defects in castings for Authority approval prior to welding any parts.

1.4 Weld Repairs of Mounting Surfaces

1.4.1 Except with written Authority approval, this Section is not applicable for stamped or forged parts; parts fabricated from quench and tempered, thermo-mechanically processed, or precipitation hardened materials; bearing surfaces; press-fit surfaces; or any surface that cannot be brought into full conformance with OEM requirements after welding and grinding or machining.

1.4.2 Nonconforming mounting surfaces shall be prepared for welding by machining or grinding. Joint preparation shall allow for sufficient opening to achieve

complete fusion at the root of the weld. The mounting location shall be free from scale, oil, dirt, and other extraneous matter.

1.4.3 The structure being welded shall be held securely during welding to prevent distortion.

1.4.4 Welding shall be performed using arc welding or Authority approved welding process.

1.4.4.1 Welding consumables such as electrode and shielding gas, shall be in accordance with AWS D1.1, D1.3, or other Authority approved industry standard for the material(s) being welded. Welding consumables are subject to Authority review.

1.4.4.2 Preheat and inter-pass temperature shall be in accordance with AWS D1.1, D1.3, or other Authority approved industry standard for the material(s) being welded. In no case shall the preheat temperature be less than 4.5°C (40°F) or the inter-pass temperature exceed 288°C (550°F).

1.4.4.3 All welding repairs shall be performed by qualified welders using qualified procedures in accordance with AWS D1.1, D1.3, or other Authority approved industry standard. Pre-qualification and use of pre-qualified welds and welding procedures is not acceptable.

1.4.4.4 Welding shall be performed in the flat position.

1.4.4.5 The Contractor shall demonstrate that the hardness of the weld deposit meets OEM requirements for the part being repaired.

1.4.5 The mounting surface shall be built up by welding to a sufficient thickness that it can be machined or ground flush to achieve a flat, defect-free surface in accordance with all OEM drawing requirements.

1.4.6 All welds shall be cooled in still air. Forced cooling of any pass or completed weldment shall not be permitted.

1.4.7 The entire weld and ½ inch of the parent material on each side shall be peened.

1.4.8 Following any specified heat treatment, the welded mounting surface shall be finished by machining or grinding. The flatness measurement of the mounting location shall be repeated to verify compliance with the specification requirements.

1.4.9 MT and VT shall be performed to identify defects such as cracks, lack of fusion, porosity, slag inclusions, or undercut.

1.4.9.1 Defects found shall be removed and repaired using an Authority approved procedure.

1.4.9.2 Wherever MT inspection is required, VT inspection shall also be performed. For non-ferromagnetic materials such as aluminum alloys, copper alloys, or austenitic stainless steel, PT shall be used in place of MT. All NDT inspection shall be performed.

1.4.9.3 The Contractor shall submit a repair procedure for repairing mounting surfaces for Authority approval prior to repairing any parts.

1.5 **Weld Repairs of Clearance Holes**

1.5.1 Except with written Authority approval, this Section is not applicable for stamped or forged parts; parts fabricated from quench and tempered, thermo-mechanically processed, or precipitation hardened materials; or any clearance hole that cannot be brought into full conformance with OEM requirements after welding and machining.

1.5.2 Nonconforming clearance holes shall be prepared for welding by grinding, if necessary. The clearance hole and surrounding area shall be free from scale, oil, dirt, and other extraneous matter.

1.5.3 The structure being welded shall be held securely during welding to prevent distortion.

1.5.4 Welding shall be performed using arc welding or Authority approved welding process.

1.5.4.1 Welding consumables such as electrode, shielding gas, and backing shall be in accordance with AWS D1.1, D1.3, or other Authority approved industry standard for the material(s) being welded. Welding consumables are subject to Authority review.

1.5.4.2 Preheat and inter-pass temperature shall be in accordance with AWS D1.1, D1.3, or other Authority approved industry standard for the material(s) being welded. In no case shall the preheat temperature be less than 4.5°C (40°F) or the inter-pass temperature exceed 288°C (550°F).

1.5.4.3 All welding repairs shall be performed by qualified welders using qualified procedures in accordance with AWS D1.1, D1.3, or other Authority approved industry standard. Pre-qualification and use of pre-qualified welds and welding procedures is not acceptable.

1.5.5 The clearance hole shall be closed by welding, either partially or completely, such that it can be reamed to meet the specification requirements for diameter, circularity, and surface finish.

1.5.6 All welds shall be cooled in still air. Forced cooling of any pass or completed weldment shall not be permitted.

1.5.7 MT and VT shall be performed to identify defects such as cracks, lack of fusion, porosity, slag inclusions, or undercut.

1.5.7.1 Defects found shall be removed and repaired using an Authority approved procedure.

1.5.8 Following any specified heat treatment, the welded hole shall be finished by reaming. The diameter and circularity measurements of the clearance hole shall be repeated to verify compliance with the specification requirements.

1.5.9 Wherever MT inspection is required, VT inspection shall also be performed. For non-ferromagnetic materials such as aluminum alloys, copper alloys, or austenitic stainless steel, PT shall be used in place of MT.

1.5.10 The Contractor shall submit a repair procedure for repairing clearance holes for Authority approval prior to repairing any parts.

1.6 Repair of Threaded Holes

1.6.1 General

1.6.1.1 Except with written Authority approval, weld repairs of threaded holes are not applicable for stamped or forged parts; parts fabricated from quench and tempered, thermo-mechanically processed, or precipitation hardened materials; or any threaded hole that cannot be brought into full conformance with OEM requirements after welding, drilling, and tapping.

1.6.2 Threaded Inserts

1.6.2.1 Where welding repairs are not applicable, or hot work would present an unacceptable risk of deformation or damage to the part, the Contractor may propose the use of threaded inserts to repair damaged threaded holes.

1.6.2.2 The application and type of threaded insert used shall be approved by the Authority on a case-by-case basis.

1.6.2.3 Threaded inserts shall be installed following the manufacturer’s installation instructions.

1.6.2.4 Threaded inserts shall be sufficiently locked to prevent undesired movement of the insert.

1.6.2.5 The Contractor shall submit, for Authority review and approval, a procedure for repairing threaded holes using threaded inserts, including requirements for drilling/reaming, tapping, and installing the threaded inserts. The Contractor's procedure shall reference the manufacturer's installation instructions.

1.6.3 **Weld Repairs of Threaded Holes**

1.6.3.1 Where welding repairs are applicable, nonconforming threaded holes shall be prepared for welding by drilling, reaming, or grinding sufficient to achieve complete weld penetration and a defect-free weld. The clearance hole and surrounding area shall be free from scale, oil, dirt, and other extraneous matter.

1.6.3.2 The structure being welded shall be held securely during welding to prevent distortion.

1.6.3.3 Welding shall be performed using arc welding or Authority approved welding process.

1.6.3.3.1 Welding consumables such as electrode, shielding gas, and backing shall be in accordance with AWS D1.1, D1.3, or other Authority approved industry standard for the material(s) being welded. Welding consumables are subject to Authority review.

1.6.3.3.2 Preheat and inter-pass temperature shall be in accordance with AWS D1.1, D1.3, or other Authority approved industry standard for the material(s) being welded. In no case shall the preheat temperature be less than 4.5°C (40°F) or the inter-pass temperature exceed 288°C (550°F).

1.6.3.3.3 All welding repairs shall be performed by qualified welders using qualified procedures in accordance with AWS D1.1, D1.3, or other Authority approved industry standard. Pre-qualification and use of pre-qualified welds and welding procedures is not acceptable.

1.6.3.4 The threaded hole shall be closed by welding, either partially or completely, such that it can be drilled and tapped to meet the specification requirements for thread profile.

1.6.3.5 All welds shall be cooled in still air. Forced cooling of any pass or completed weldment shall not be permitted.

1.6.3.6 MT and VT shall be performed to identify defects such as cracks, lack of fusion, porosity, slag inclusions, or undercut.

1.6.3.6.1 Defects found shall be removed and repaired using an Authority approved procedure.

1.6.3.7 Following any specified heat treatment, the welded hole shall be finished by drilling and tapping. Checking of the threads using a go/no-go gauge shall be repeated to verify compliance with the specification requirements.

1.6.3.8 Wherever MT inspection is required, VT inspection shall also be performed. For non-ferromagnetic materials such as aluminum alloys, copper alloys, or austenitic stainless steel, PT shall be used in place of MT.

1.6.3.9 The Contractor shall submit a repair procedure for weld repair of threaded holes for Authority approval prior to repairing any parts using this process.

1.7 Weld Repairs of Secondary Brackets

1.7.1 The base material shall be prepared for welding by cutting or grinding. Existing brackets shall be removed from the base material and remaining weld deposit shall be ground flush to the surface. The repair area shall be free from scale, oil, dirt, and other extraneous matter.

1.7.2 Jigs or fixtures shall be used to accurately position secondary brackets. The structure being welded shall be held securely during welding to prevent distortion.

1.7.3 The secondary bracket shall be welded to the base material using weld preparation and joint geometry consistent with OEM requirements.

1.7.4 Welding shall be performed using arc welding or Authority approved welding process.

1.7.4.1 Welding consumables such as electrode, shielding gas, and backing shall be in accordance with OEM requirements, where applicable, AWS D1.1, D1.3, or other Authority approved industry standard. Any welds between carbon or low alloy steel and stainless steel shall be performed using an electrode capable of producing an austenitic stainless steel weld deposit. Welding consumables are subject to Authority review.

1.7.4.2 Preheat and inter-pass temperature shall be in accordance with AWS D1.1, D1.3, or other Authority approved industry standard for the material(s) being welded. In no case shall the preheat temperature be less than 4.5°C (40°F) or the inter-pass temperature exceed 288°C (550°F).

1.7.4.3 All welding repairs shall be performed by qualified welders using qualified procedures in accordance with AWS D1.1, D1.3, or other Authority approved industry standard. Pre-qualification and use of pre-qualified welds and welding procedures is not acceptable.

1.7.4.4 Where possible, welding shall be performed in the flat position. All other positions require additional weld and welder qualifications. Vertical welding is permitted only in the up direction.

1.7.5 All welds shall be cooled in still air. Forced cooling of any pass or completed weldment shall not be permitted.

1.7.6 MT and VT shall be performed to identify defects such as cracks, lack of fusion, porosity, slag inclusions, or undercut.

1.7.6.1 Defects found shall be removed and repaired using an Authority approved procedure.

1.7.7 As a final operation, all welds and ½ inch of the parent material on each side of the welds shall be peened.

1.7.8 Wherever MT inspection is required, VT inspection shall also be performed. For non-ferromagnetic materials such as aluminum alloys, copper alloys, or austenitic stainless steel, PT shall be used in place of MT.

1.7.9 The Contractor shall submit a repair procedure for replacing secondary brackets for Authority approval prior to repairing any parts.

1.8 **Weld Qualifications**

1.8.1 All welds shall be performed using qualified Weld Procedure Specifications (WPS) in accordance with the requirements of AWS D1.1, D1.3, ASTM A488, or other Authority approved industry standard.

1.8.2 All WPS shall be qualified by the Contractor or Subcontractor who will be performing the welds. Qualification samples shall be welded at the Contractor or Subcontractor's facility using the procedures, consumables, and welding equipment that will be used for all welds performed during the manufacture of the drop axle.

1.8.2.1 Backing material, if used, shall be the same as for welds performed during the manufacture of the drop axle.

1.8.2.2 Weld qualifications shall include impact toughness testing performed using Charpy V-Notch specimens. Impact toughness in the weld heat affected zone (HAZ) shall be greater than 27J (20ft-lbs) at -30°C (-22°F).

1.8.2.3 Weld qualifications shall be recorded on a Procedure Qualification Record (PQR) providing the weld parameters used and results of all tests and inspections performed in support of the qualification.

1.8.2.4 The use of a WPS purchased from AWS or any other source is not permitted. Pre-qualification and use of pre-qualified welds and welding procedures is not acceptable.

1.8.3 All welders shall be qualified in accordance with the requirements AWS D1.1, D1.3, ASTM A488, or other Authority approved industry standard. Written welder qualification test records (WQTR) shall be made available for review at the Authority's request.

1.8.4 All WPS and PQR, along with specifications for purchase of welding consumables, shall be submitted for Authority approval prior to performing any welding on Authority owned equipment.

1.9 **Straightening**

1.9.1 Where possible, straightening shall be used to correct dimensional nonconformities. The Contractor shall be responsible for determining the applicability of cold or hot straightening and ensuring that straightening operations do not cause cracking, tearing, or other defects in the part being straightened.

1.9.1.1 Cold straightening shall be used to correct minor dimensional nonconformities only.

1.9.1.2 Hot straightening shall be used to correct larger dimensional nonconformities.

1.9.2 The following requirements apply to hot straightening:

1.9.2.1 The Contractor shall set maximum limits for straightening temperature, based on industry standards or testing performed by the Contractor, for each material that that will be hot straightened. The maximum straightening temperature shall not cause residual changes to the mechanical properties of the material being straightened. For quench and tempered materials, the straightening temperature shall not exceed the tempering temperature.

1.9.2.2 Temperature measurements shall be performed by means of contact or non-contact thermometers. If non-contact thermometers are used, calibration shall be performed at the maximum straightening temperature for each combination of material and surface finish.

1.9.2.3 If heating is applied using a torch, nozzles and heating technique shall be such that temperature gradients are limited, and heating is distributed across the part being straightened. Localized melting of the material surface shall not be permitted.

1.9.2.4 If heating is applied using a torch, the torch shall be adjusted for a neutral flame. Carburizing flames shall not be permitted.

1.9.2.5 All parts shall be cooled in still air following hot straightening. Forced cooling shall not be used.

1.9.3 After cold or hot straightening, the entire straightened part shall be visually inspected. Additionally, MT or PT shall be performed surrounding the locations of force application, mechanical fixation, and heat application, if used.

1.9.3.1 The locations of force application, mechanical fixation, and heat application shall be recorded, along with inspection results, and included in applicable History Books

1.9.3.2 If defects are found after straightening, the Authority shall be notified immediately and the Contractor shall develop a repair procedure. The repair procedure shall be submitted and approved by the Authority in writing prior to the Contractor starting repairs.

1.9.4 The Contractor shall submit a straightening procedure, including maximum temperature limits where applicable, for Authority approval prior to performing any straightening operations.

1.10 Stress Relief Heat Treatment

1.10.1 Local Heat Treatment

1.10.1.1 Drop axles shall be held securely during stress relief heat treatment to prevent distortion.

1.10.1.2 Heat treatment stress relief processes shall utilize equipment capable of accurately controlling, monitoring, and recording temperatures throughout the heat treatment area with the ability to calibrate for maximum accuracy.

1.10.1.3 Thermocouples shall be spot welded directly to the surfaces to be heat treated. If multiple areas will be heat treated simultaneously, at least one

thermocouple shall be used at each location. The control system shall have a sufficient number of heating elements and temperature measuring devices to accurately measure and correct temperature deviations within the heat treatment area to ± 50°F for each process step.

1.10.1.4 Wrap the area to be heat treated with electric heating elements. Heating elements shall extend past the area to be heat treated equally in all directions to ensure uniform temperature across the area being heat treated.

1.10.1.5 Wrap the heating elements with an insulating blanket. Extend the insulating blanket past the heating elements equally in all directions to establish a gradient control band.

1.10.1.5.1 Where possible, insert insulation inside of closed sections to ensure uniform heating through the thickness of the shell around the closed section.

1.10.1.6 Heat treatment shall be performed as follows:

1.10.1.6.1 Ramp temperature from room temperature to between 1025°F and 1075°F at no more than 200°F per hour.

1.10.1.6.2 Hold between 1025°F and 1075°F for 3 hours.

1.10.1.6.3 Ramp temperature back to room temperature at no more than 175°F per hour.

1.10.1.7 Visual inspection and NDT surface inspection (MT or PT) shall be performed on all locally heat-treated areas.

1.10.1.8 A local heat-treating procedure shall be submitted for Authority review prior to heat treating any parts.

1.10.1.9 Temperature profiles from stress relief heat treatment shall be included by the Contractor as part of the applicable History Books.

1.10.1.10 Stress relief using a manual torch shall not be permitted.

1.10.2 **Furnace Heat Treatment**

1.10.2.1 Drop axles shall be held securely during stress relief heat treatment to prevent distortion.

1.10.2.2 The furnace shall utilize equipment capable of accurately controlling, monitoring, and recording temperatures throughout the heat treatment area with the ability to calibrate for maximum accuracy. The furnace

temperature shall be controlled by the thermocouples spot welded to the part being heat treated, not by the air temperature in the furnace.

1.10.2.3 Thermocouples shall be spot welded directly to the surfaces to be heat treated. Multiple thermocouples shall be used per part to monitor the temperature distribution across the part.

1.10.2.4 Insert the part to be heat treated into the furnace at a location that ensures uniform heating of the part. If multiple parts are being heat treated simultaneously, they may not be stacked directly on top of one another.

1.10.2.5 Heat treatment shall be performed as follows:

1.10.2.5.1 Ramp temperature from room temperature to between 1075°F and 1125°F at no more than 400°F per hour.

1.10.2.5.2 Hold between 1075°F and 1125°F for ½ hour.

1.10.2.5.3 Ramp temperature back to room temperature at no more than 300°F per hour.

1.10.2.6 Visual inspection shall be performed on all furnace heat treated parts.

1.10.2.7 A furnace heat treating procedure shall be submitted for Authority review prior to heat treating any parts.

1.10.2.8 Temperature profiles from stress relief heat treatment shall be included by the Contractor as part of the applicable History Books.

1.11 Painting and Corrosion Protection

1.11.1 The Contractor is responsible for ensuring that all components have sufficient protection against corrosion under the expected service and environmental conditions. To demonstrate compliance with this requirement, the Contractor shall develop a Corrosion Protection Plan that incorporates all Specification and OEM requirements, along with general requirements for items not covered by the Specification or OEM documentation. The Corrosion Protection Plan shall be submitted for Authority approval and shall, at a minimum, include the following information.

1.11.1.1 Type of primer, paint, powder coat, sealant, anti-seize, plating, passivation, or other means of corrosion protection used for each component.

1.11.1.2 Technical and material safety data sheets for all primers, paints, sealants, anti-seize, or other chemicals used.

1.11.1.3 Coating, anti-seize, and sealant configuration, showing the application locations and types of coatings, anti-seize, and sealants used.

1.11.1.4 Procedures for each coating and sealant process, including surface preparation, temperature and humidity, coating thickness, and drying time requirements.

1.11.1.5 Record sheets for each coating and sealant process.

1.11.1.6 Coating and/or plating adhesion test results.

1.11.2 Unless otherwise required by this Specification or OEM documentation, exterior surfaces of the drop axle shall be coated using zinc chromate alkyd primer with compatible black enamel, or Authority-approved alternate coating system. The coating system shall not conceal structural cracks that may develop in service.

1.11.2.1 Unless specifically noted otherwise, equipment mounting locations, bearing surfaces, clearance holes, threaded holes, ground pads, nameplates, and other areas that are at risk for embedment or wear particulate formation shall not be coated.

1.11.2.2 Prior to performing any coating process, surfaces not to be coated shall be masked or covered to prevent inadvertently coating the surface due to overspray or runs.

1.11.2.3 Prior to performing any coating, surfaces to be coated shall be cleaned of all oil, dirt, dust, and other foreign matter to a level necessary to meet the coating manufacturer's surface preparation requirements.

1.11.2.4 Coatings shall be applied as recommended by the manufacturer using the number of coats recommended by the manufacturer. Dry film thickness shall meet the manufacture's recommendations.

1.11.2.5 Coating adhesion shall be tested per the latest revision of ASTM D3359 on a sample of each combination of base material and coating system using the same surface finish and coating process that will be used for drop axle. Adhesion shall achieve a maximum rating as provided by the coating manufacturer.

1.11.3 Sealant shall be applied per the OEM configuration, except that any additional areas deemed by the Contractor or Authority to pose a risk for water intrusion shall be sealed.

1.11.3.1 Prior to applying sealant, surfaces to be sealed shall be cleaned of all oil, dirt, dust, and other foreign matter to a level necessary to meet the sealant manufacturer's surface preparation requirements.

1.11.4 Joints between dissimilar metals shall be protected against galvanic corrosion by isolating the dissimilar metals using an Authority approved process.

1.11.5 Unless otherwise required by this Specification or OEM documentation, zinc plating shall be in conformance with ASTM B633 for service condition SC2, SC3, or SC4 with a Type II or Type VI finish.

1.11.5.1 Other plating processes may be submitted for Authority approval, provided they are able to withstand a minimum of 96 hours salt spray exposure without developing red rust or visible corrosion products. Salt spray testing shall be performed in accordance with ASTM B117.

1.11.6 Passivation or other means of corrosion protection shall be performed in accordance with an Authority approved industry standard.

1.12 **Grit Blasting**

1.12.1 Grit blasting shall be performed using non-destructive ceramic media such as ceramic beads, DuPont Star Blast, or other Authority-approved ceramic medium with rounded to sub-angular grains. Aluminum Oxide is not an acceptable grit blast medium.

1.12.2 Prior to grit blasting, all surfaces not to be blasted shall be protected to prevent damage from overspray.

1.12.2.1 Unless specifically noted otherwise, equipment mounting locations, bearing surfaces, clearance holes, threaded holes, ground pads, nameplates and other areas where a smooth surface finish is required shall not be grit blasted.

1.12.3 The Contractor shall submit a grit blasting procedure for Authority approval prior to grit blasting any parts.

1.13 **Cleaning and Stripping**

1.13.1 All manufactured components shall be cleaned of oil, grease, dirt, dust, and other foreign matter.

1.13.2 Paint shall be stripped from manufactured components as required by this Specification or the SMOM.

1.13.3 Cleaning and stripping may be achieved through chemical or mechanical means.

1.13.3.1 Where cleaning and stripping are achieved through mechanical means, care shall be taken not to damage the surface being cleaned or stripped. The final surface finish shall be in accordance with OEM requirements.

1.13.3.2 Where cleaning and stripping are achieved through chemical means, the chemical being used for cleaning or stripping shall be compatible with the surface being cleaned or stripped. Any nearby components that may be damaged by the cleaning or stripping chemicals shall be protected to prevent contact with the chemicals.

1.13.4 All surrounding locations that do not require cleaning or stripping shall be adequately protected during the cleaning and stripping operations.

1.13.5 Cleaning and stripping processes shall achieve cleanliness appropriate for the application.

1.13.5.1 For coating or sealant applications, cleanliness shall be in accordance with the coating or sealant manufacturer's recommendations.

1.13.5.2 For welding applications, cleanliness shall be in accordance with the applicable AWS code.

1.13.5.3 Cleanliness shall meet OEM requirements where available.

1.13.5.4 For other applications, cleanliness shall be in accordance with an Authority-approved SSPC or NACE standard.

1.13.6 The Contractor shall submit a Cleaning and Stripping Plan for Authority approval prior to cleaning or stripping any parts.

1.14 Leak Testing

1.14.1 Water Tightness Testing

1.14.1.1 Prior to performing the leak test, the hydraulic system shall be filled with hydraulic fluid and bled to remove any air within the system.

1.14.1.2 After making repairs, the entire leak test shall be repeated to verify that repair work did not cause any additional leaks.

1.14.1.3 The Contractor shall submit a procedure for pneumatic system leak testing as needed, including test pressures and acceptance criteria, for Authority review and approval.

1.15 Dimensional Inspection

1.15.1 Dimensional inspections shall be performed by qualified personnel using tools with sufficient accuracy and precision to identify conforming and

nonconforming components. Inspection tools shall be kept in current calibration.

1.15.2 Dimensional inspection acceptance/rejection criteria shall be in accordance with the OEM requirements. At a minimum, the following items shall be inspected:

1.15.2.1 Where specified, surface finish, flatness, and profile shall be inspected.

1.15.2.2 Clearance holes for equipment mounting shall be inspected for diameter and circularity.

1.15.2.3 Machined bores, bosses/pins, and guide shafts shall be inspected for diameter, depth/length, circularity, concentricity, and surface finish.

1.15.2.4 Rotating shafts shall be inspected for diameter and runout.

1.15.2.5 Threaded holes and bosses shall be inspected for damaged, oversized, or undersized threads using go/no-go gauges. Unless otherwise specified by the OEM, threaded holes and bosses shall conform to the dimensional requirements of ASME B1.1, Class 2.

1.15.2.6 Where specified or included on OEM drawings, parallelism, perpendicularity, and concentricity shall be inspected.

1.15.2.7 Dimensional inspection shall check for bent or distorted components.

1.15.3 Procedures calling for dimensional inspection shall show the dimension to be measured, list the tool to be used for inspection, and provide nominal, minimum acceptable, and maximum acceptable values for each dimensional measurement.

1.15.4 The results of all dimensional measurements shall be recorded in the applicable History Books provided by the Contractor.

1.16 **Electrical Wiring**

1.16.1 All wiring shall be performed by qualified, experienced wiring personnel using appropriate tools for stripping insulation, cutting, tinning, soldering, harness making, attaching terminals, and other wire fabrication tasks.

1.16.2 Wire shall be protected from damage during all phases of equipment manufacture.

1.16.2.1 Wire shall not be walked on, dragged across sharp or abrasive objects, kinked or twisted, or otherwise mishandled.

1.16.2.2 The ends of wire shall not be permitted to lay on wet floors or other damp areas where moisture may be absorbed into the conductors.

1.16.3 There shall be no nicks in the insulation of any wire or cable.

1.16.3.1 Wire and cable with nicked or otherwise damaged insulation shall be replaced.

1.16.3.2 In isolated cases, a repair procedure may be proposed in lieu of replacement, subject to review and approval of the Authority. Such approval will not be granted for Teflon-based insulation or where the depth of the nick is greater than 50 percent of the insulation thickness.

1.16.4 When removing insulation, wire strands shall not be nicked or broken in excess of the limits of FAA Specification No. AC 43.13-1A, Section 449, “Stripping Insulation.” Additionally, the following criteria shall apply:

1.16.4.1 Wires smaller than AWG No.10 shall have no nicked or broken strands.

1.16.4.2 AWG No.10 through AWG 1/0 shall be allowed 7.4 percent nicked strands.

1.16.4.3 Above AWG 1/0 through 1600/24 shall be allowed 4.4 percent nicked strands.

1.16.4.4 Above AWG 1600/24, nicked strands shall be allowed on a graduated scale.

1.16.4.5 Definitions: A broken strand shall count as two nicked strands. A nick is defined as 25 percent or more of the strand area damaged or cut more than 33 percent of its diameter. Longitudinal scratches in a copper strand are not considered cause for rejection.

1.16.5 Cable conductors shall be clean prior to installation of terminals, lugs, or connectors.

1.16.6 Terminals, lugs, and connectors shall be attached to the wiring using the proper crimping tools and dies recommended by the manufacturer. Only one wire shall be crimped in any one terminal.

1.16.6.1 Swaging tools shall be of a type that ensures complete swaging in every case.

1.16.7 If used, solder shall be in accordance with ASTM B32, Grade Sn60. A non-corrosive flux shall be applied immediately before soldering.

1.16.8 All terminals shall be properly torqued to assure sound connections.

1.16.9 Conductors which may be subjected to motion relative to the terminal shall be protected by suitable means to prevent breakage of the conductor at or near the terminal.

1.16.10 Wires and cables shall not be allowed to chafe or rub against any part of the truck, wireway, conduit, or each other.

1.16.11 Wire and cable dress shall allow for sufficient slack at equipment terminals to provide for movement induced by shock and vibration, equipment shifting, alignment, cover removal, and component replacement.

1.16.12 A drip loop shall be provided on all exposed wires and cables to prevent fluid runoff into connected equipment.

1.16.13 Pulling compound, is used, shall be non-conductive, non-hygroscopic, non-odorous, shall not support bacterial activity, nor attract vermin.

1.16.14 Electrical tape shall not be PVC. Electrical tape shall meet or exceed the voltage rating of wire where the tape is applied.

1.16.15 An anti-corrosive grease shall be applied to the contacting surfaces of all ground connections.

1.16.16 Wire-tying devices shall be of such material and construction that they will adequately retain the wires for the life of the wiring and shall be resistant to ozone and ultraviolet light.

1.16.16.1 Wire and cable ties shall be trimmed and located to eliminate any hazard to personnel or risk of chafing/cutting adjacent wires due to sharp edges.

1.16.16.2 Wire-tying devices shall be snug but shall not be so tight as to cause indentation and cold flow damage to insulation.

1.16.16.3 Wire-tying devices shall be mechanically fastened to a permanent structure. Adhesive-installed mounting bases shall not be used for ties or for cable support.

1.17 Electrical Testing

1.17.1 General

1.17.1.1 The Contractor shall submit an electrical testing procedure, including acceptance criteria and test voltage/time, for Authority review and approval.

1.17.2 **Wiring Continuity**

1.17.2.1 All circuits shall be tested to ensure continuity and correct polarity of equipment and devices. All frame grounds and terminal connections shall be checked for tightness.

1.17.3 **Insulation Resistance**

1.17.3.1 Insulation resistance tests shall be conducted on all electrical wiring and connections. Tests shall be conducted to verify the state of the insulation to the case or frame.

1.17.3.2 The following insulation resistance limits shall apply when all circuits of a given voltage class are connected in parallel under all environmental conditions, including high humidity. Measurements shall be taken after applying constant voltage for 1 minute.

1.17.3.2.1 Where the nominal circuit voltage is below 90 V, the minimum insulation resistance shall be 2 megohm at 500 Vdc.

1.17.3.2.2 Where the nominal circuit voltage is 90 to 300 V, the minimum insulation resistance shall be 4 megohm at 1000 Vdc.

1.17.3.2.3 Where the nominal circuit voltage is above 300 V, the minimum insulation resistance shall be 5 megohm at 1000 Vdc.

1.17.4 **High Potential Tests**

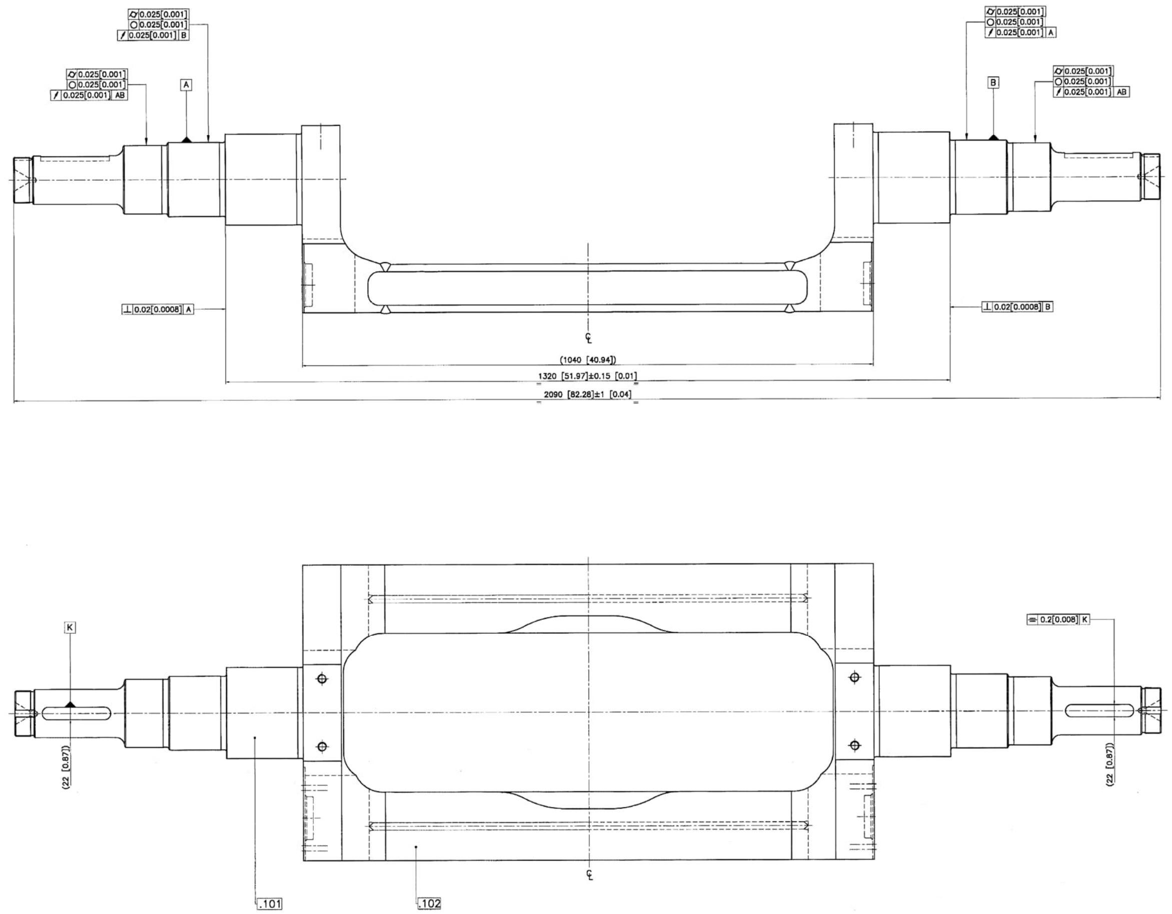
1.17.4.1 High potential tests shall be conducted only once the insulation resistance tests are completed and passed. Tests shall be conducted to verify the state of the insulation to the case or frame.

1.17.4.2 The test shall be conducted by applying the test voltage, as listed below, for a period of 1 minute, across the insulation being tested. The test is passed if there is no insulation breakdown or excessive leakage current. The test voltage shall be at a frequency of 50 or 60 Hz with a sinusoidal waveform. Alternatively, the test voltage can be dc with a value equal to 1.414 times the ac rms voltage. In the formula below, V shall be the nominal system voltage for a circuit.

1.17.4.2.1 If the nominal circuit voltage is below 300 V, the test voltage shall be 2*V + 1000 Volts.

1.17.4.2.2 If the nominal circuit voltage is equal to or above 300 V, the test voltage shall be 2.25*V + 2000 Volts.

END OF DOCUMENT



L'ASSILE DEVE ESSERE CONFORME ALLA SPECIFICA BREDA LPC/STE/9610255-J36/T.09.C07.
THE AXLE SHALL BE IN ACCORDANCE WITH BREDA DOCUMENT LPC/STE/9610255-J36/T.09.C07.

*-NOTA: RESILIENZA 27J A -30°C
*-NOTE: RESILIENCE 27J AT -30°C

TUTTE LE SALDATURE, SE NON DIVERSAMENTE INDICATE, SONO CLASSIFICATE B 1

ALL WELDS, IF UNLESS DIFFERENTLY INDICATED, ARE CLASSIFIED B 1

LIVELLO DI CRITICITA' DEL GIUNTO / WELDED JOINT CRITICALITY LEVEL
CLASSE DI SALDATURA / WELDING CLASS
SECONDO DOC. SQU 279 / AS DOC. SQU 279

PREPARAZIONE DEI LEMBI DA SALDARE VEDI MATR.: J35-2.00.020
PREPARATION EDGE AS FOR FILE: J35-2.00.020

USATO NELLA MATRICOLA / REFERENCE TO N.H.A. 2.54.000

MATR. FILE	REV. REV.	LC CL.	Q.TY REQD.	DENOMINAZIONE DESCRIPTION	DIMENS.UNIFIC./RIFERIM. SIZE STANDARDS REFERENCES	SIMBOLO SYMBOL (MATERIALE / MATERIAL)	TRATTAMENTO TREATMENT	LC CL.	KG.	LBS. (UNITARY WEIGHT)
.102		1	2	TRAVERSA TRANSOM		Fe 510 D1 UNI EN 10025 [*]		1	22,4	49,38
.101		1	2	FUSELLO SPINDLE		25 CrMo 4 UNI EN 10083/1 [*]		1	131,8	290

DISEGNO ESEGUITO CON CAD : SONO VIETATE MODIFICHE O CORREZIONI MANUALI
DRAWING PROCESSED BY CAD EQUIPMENT : ANY MODIFICATIONS OR HAND WRITTEN CORRECTIONS ARE PROHIBITED

TOLLERANZE: [illegible]
TOLERANCES: UNLESS OTHERWISE SPECIFIED TOLERANCES SHALL BE AS PER TAB. F.3610 OR 8475 (PLASTIC). TOLERANCES ON ANGULAR DIMENSIONS AS PER TAB. UNI ISO 2768.

REV. REV.	DATA DATE	DISEGNATO DRAWN	VERIFICATO CHECKED	APPROVATO APPROVED	DESCRIZIONE DESCRIPTION
4	08.04.97	F.CICCONI	D.SPINELLI	F.GHERARDI	REVISIONE GENERALE / GENERAL REVISION
3	27.02.97	F.CICCONI	D.SPINELLI	F.GHERARDI	[illegible]
2	21.11.96	F.CICCONI	D.SPINELLI	F.GHERARDI	MODIFICATO DETTAGLIO "G" E GIUNTI 205 - 215. / MODIFIED DETAIL "G" AND JOINTS 205 - 215.
1	24.10.96	F.CICCONI	D.SPINELLI	F.GHERARDI	REVISIONE GENERALE / GENERAL REVISION
0	26.09.96	GM/F.CICCONI	D.SPINELLI	F.GHERARDI	PRIMA EMISSIONE FASE ESECUTIVA / FIRST ISSUE EXECUTIVE PHASE

SCALA / SCALE 1:2.5 | UGUAGLIANZE / EQUALITIES | PESO UNITARIO / UNITARY WEIGHT Kg. 308,40 Lbs. 678,00 | FORMATO/SIZE E | FOGLIO / SHEET 1 DI / OF 2 | TIPO / TYPE J36

MATR. / FILE 2.54.100

DESCRIZIONE / DESCRIPTION LFC -- BOSTON MBTA

BREDA COSTRUZIONI FERROVIARIE

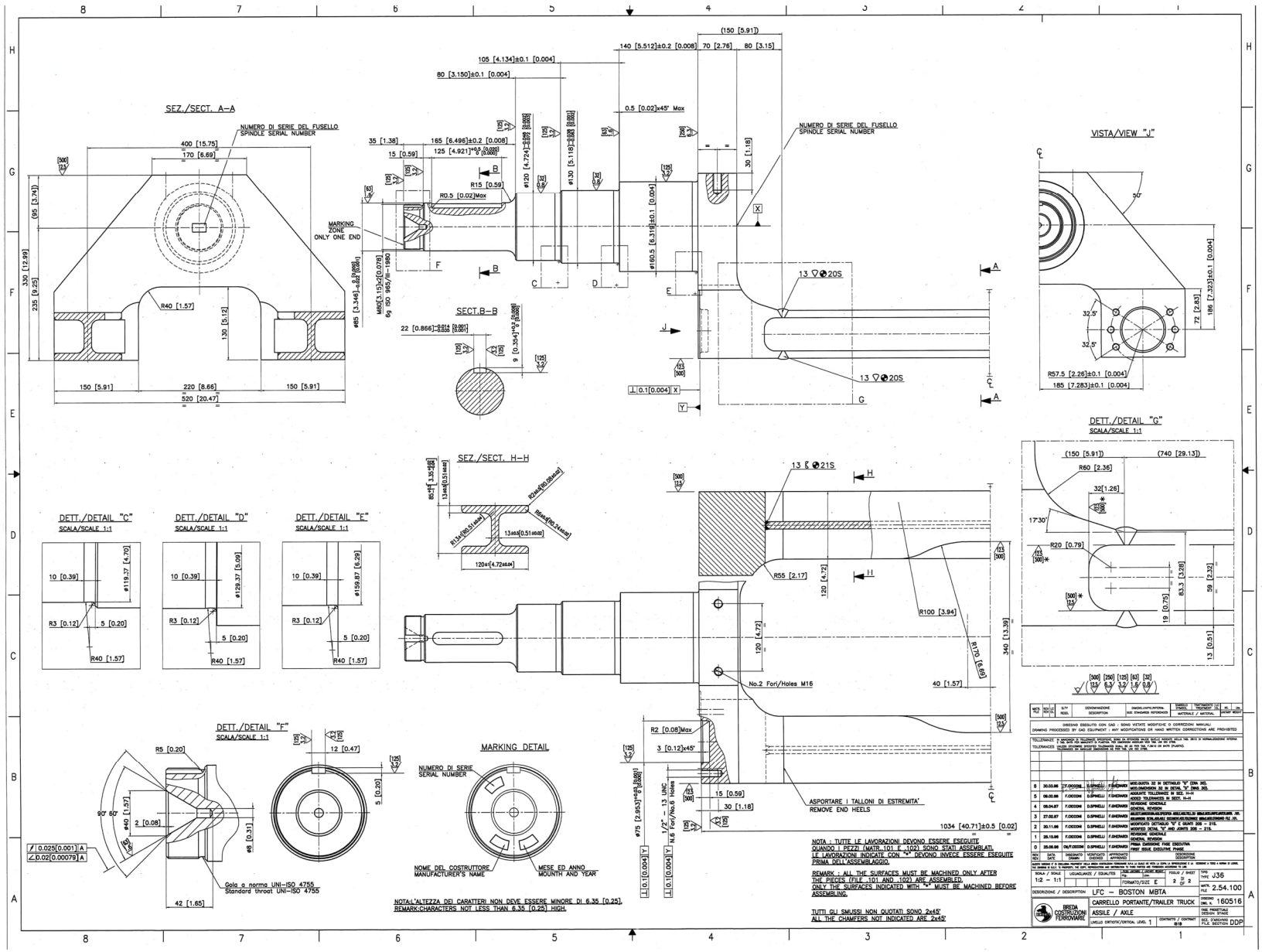
CARRELLO PORTANTE/TRAILER TRUCK

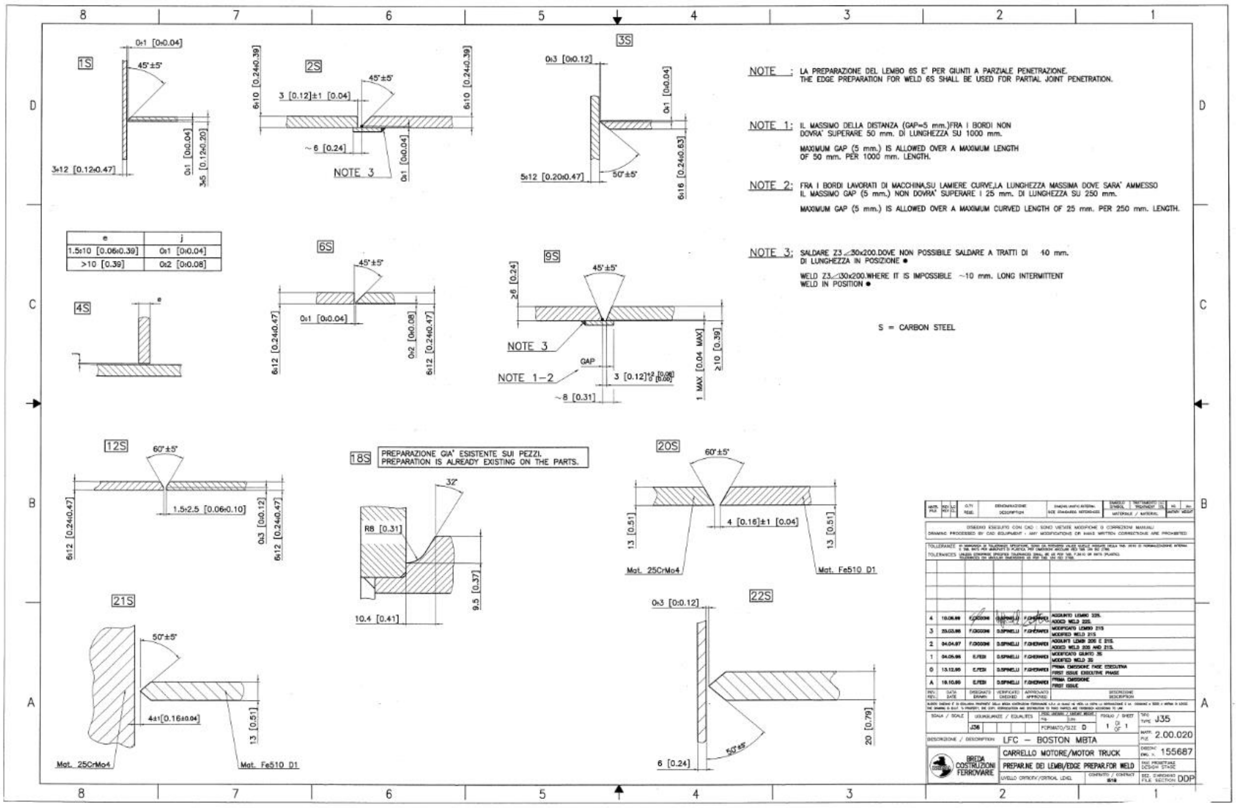
ASSILE / AXLE

DISEGNO / DWG. N. 160516

FASE PROGETTUALE / DESIGN STAGE E

LIVELLO CRITICITA'/CRITICAL LEVEL 1 | CONTRATTO / CONTRACT 6518 | SEZ. D'ARCHIVIO / FILE SECTION DDP


SEZ./SECT. A–A
NUMERO DI SERIE DEL FUSELLO
SPINDLE SERIAL NUMBER
MARKING ZONE ONLY ONE END
SECT.B–B
VISTA/VIEW "J"
DETT./DETAIL "C"
SCALA/SCALE 1:1
DETT./DETAIL "D"
SCALA/SCALE 1:1
DETT./DETAIL "E"
SCALA/SCALE 1:1
SEZ./SECT. H–H
DETT./DETAIL "F"
SCALA/SCALE 1:1
MARKING DETAIL
NUMERO DI SERIE
SERIAL NUMBER
NOME DEL COSTRUTTORE
MANUFACTURER'S NAME
MESE ED ANNO
MOUNTH AND YEAR
DETT./DETAIL "G"
SCALA/SCALE 1:1
No.2 Fori/Holes M16
ASPORTARE I TALLONI DI ESTREMITA'
REMOVE END HEELS
Gola a norma UNI–ISO 4755
Standard throat UNI–ISO 4755
NOTA: TUTTE LE LAVORAZIONI DEVONO ESSERE ESEGUITE QUANDO I PEZZI (MATR..101 E ..102) SONO STATI ASSEMBLATI. LE LAVORAZIONI INDICATE CON "*" DEVONO INVECE ESSERE ESEGUITE PRIMA DELL'ASSEMBLAGGIO.
REMARK : ALL THE SURFACES MUST BE MACHINED ONLY AFTER THE PIECES (FILE ..101 AND ..102) ARE ASSEMBLED. ONLY THE SURFACES INDICATED WITH "*" MUST BE MACHINED BEFORE ASSEMBLING.
TUTTI GLI SMUSSI NON QUOTATI SONO 2x45°
ALL THE CHAMFERS NOT INDICATED ARE 2x45°
NOTA:L'ALTEZZA DEI CARATTERI NON DEVE ESSERE MINORE DI 6.35 [0.25].
REMARK:CHARACTERS NOT LESS THAN 6.35 [0.25] HIGH.
DISEGNO ESEGUITO CON CAD / SONO VIETATE MODIFICHE O CORREZIONI MANUALI
DRAWING PROCESSED BY CAD EQUIPMENT / ANY MODIFICATIONS OR HAND WRITTEN CORRECTIONS ARE PROHIBITED
BREDA COSTRUZIONI FERROVIARIE
CARRELLO PORTANTE/TRAILER TRUCK
ASSILE / AXLE
LFC – BOSTON MBTA
J36
2.54.100
160516
DDP



e	j
1.5÷10 [0.06÷0.39]	0÷1 [0÷0.04]
>10 [0.39]	0÷2 [0÷0.08]

11.6.3 Identification

Tire marking shall be in accordance with Figure 4 and hub markings shall be in accordance with Figure 5 of the AAR Specification M-107. Both tires and hubs shall be serialized. The list of serial numbers shall be provided by the Contractor. The list shall be organized to show wheel hub, tire, and axle serial numbers and the truck assembly serial number in which each is installed.

11.7 AXLES

11.7.1 General Requirements

The axles shall be of the solid or hollow design. The axle shall be designed to have a fatigue life of not less than 30 years. For all interference fits on the axle, the pressed-on part shall overhang its respective seat on the axle. Both ends of each axle shall be chamfered and furnished with standard 60 lathe centers as shown in Section 20, Drawing No. 13. Axles for two wheel trucks shall be designed for 30 years life and appropriate to the low floor car design.

The Authority shall be furnished with copies of all reports required by AAR Specification M-101, which shall be incorporated in the Car History Book.

11.7.2 Design Considerations

For an inboard bearing design, the calculated maximum static unit stress at the bearing center shall not exceed 6,000 psi when the axle is considered a simple beam under AW3 load. Outboard bearing axle designs shall conform to the requirements of AAR Standards S-014 and S-042.

The Contractor shall submit to the Authority a load diagram and static and dynamic stress calculations for the axles, which shall show, at a minimum, the maximum value of stresses to which the axles are expected to be subjected in service, and a prediction of the axle's fatigue life using a cumulative damage or other approved calculation method. The Contractor shall consider the effect of the bending loads induced by the presence of restraining rails in the axle bending fatigue stress calculations.

11.7.3 Manufacturing Requirements

Solid axles shall be manufactured in accordance with AAR M-101, Grade F except as otherwise required by this Specification. Hollow axles, if used, shall be manufactured in accordance with AAR M-101, Grade H. All axles shall be given a sub-critical quench heat treatment. Solid axles shall meet Grade F yield strength requirements after sub-critical quench. **The Contractor may propose alternative** ECP54 **material according to his experience for Authority approval.**

Wheel seats, bearing seats, gearbox resilient coupling seats, and ground brush seats shall be free from tool marks and scratches, and shall provide for interchangeability of couplings and bearings. The finish of the axle at the wheel seats, bearing seats and gearbox resilient coupling seat shall not exceed 32-microinches RMS surface roughness. Hollow axles shall have a machined interior finish not exceeding 250-microinches RMS surface roughness. All other areas of the axle shall have a surface finish not exceeding 125-microinches RMS surface roughness.

There shall be approved stress-relief profiles or radii at the ends of seats, or stress-relief grooves between adjacent seats. All stress-relief radii and grooves shall be cold-rolled to a bright surface by an approved process.

11.7.4 Axle Tolerances

The tolerance on the wheel seat diameter shall not exceed +0.001-inch, -0.000-inch. Wheel, bearing and coupling or gear seats shall be concentric, with runout not exceeding 0.001-inch.

11.7.5 Identification

Each axle shall be permanently marked with the information required by AAR M-101, Figure 4. If motor truck, trailer truck, or two wheel truck axles are not identical, they shall have different numbering sequences. The Contractor shall furnish the Authority with a record of the manufacturer's serial and heat numbers listed together with the appropriate serial numbers of the vehicles and trucks on which they have been installed.

11.8 WHEEL-AXLE ASSEMBLY

11.8.1 General Requirements

The wheels, bearings, gearbox couplings, grounding rings, and disc hubs shall be fitted to the axle by pressing. The wheel hub and gearbox couplings shall be installed with a press fit in accordance with standard AAR practice. For outside bearing trucks, wheels and bearings shall be installed in accordance with AAR standard practice in Section G, Part II, Mandatory Rules Governing Wheel Shop Practice As Required By Interchange Rules.

For inside bearing trucks, wheel bearings shall be pressed on and seated firmly against axle stops. Axle-bearing fits and pressing forces shall conform to AAR standard practice in Section G, Part II, except that the bearing press-on and seating force shall be 25 to 30 tons total pressing tonnage. Bearing press-on and seating forces shall be evident in the pressure graph. Wheel pressing tonnages shall conform to AAR standard practice, except that a residual clamping load on the bearing assembly shall be obtained by a spike force on the wheel of 25 tons, minimum. This spike force must be clearly visible on the pressure graph.

11.8.2 Pressing Requirements and Tolerances

Pressure graphs of all gear coupling, disc hub, grounding ring, bearing, and wheel to axle pressings shall be furnished to the Authority. The graphs obtained shall correspond with those shown as "acceptable" or better in Section 2 c), Wheel Press Practice of the AAR's Wheel and Axle Manual. Prior to pressing on either wheels or gear couplings, the seats and couplings shall be prepared as described in the AAR's Wheel and Axle Manual.

The wheel-axle assembly shall meet the following requirements after all pressing operations are completed:

- The mounted wheel back-to-back dimension shall be in accordance with MBTA requirements. This also applies to non-powered, two or four wheel center trucks using stub axles.
- Each full length tire-wheel-axle assembly shall provide a maximum shunting resistance of 0.01 ohm when measured from tire tread to tire tread. Maximum wheel tire tread to axle resistance for assembled stub axle wheel units shall be 0.005 ohm.
- Each full length wheel-axle assembly shall be supported and rotated on its bearings. Concentricity, when measured as near as possible to the center and at each end of each axle, shall not exceed 0.003-inch TIR at each location.
- When the wheel-axle assembly are rolled on their journal bearings, the treads
- shall have less than 0.020-inch TIR radial runout and less than 0.024-inch A2
- TIR lateral runout.

1. GENERALITIES

1.1 Object

Object of this specification is the cranked axle to fit out the trailer trucks on the Boston LFC.

1.2 Purpose

In this document are defined the characteristics required to the element in object.

1.3 Description of the supply

For each vehicle the supply shall be composed by the following items:

- N. 2 Cranked Axles

The element file is J36/2.54.100.

Moreover, the documentation required in the next Sections 3.2.4, 3.3.3, 3.4.5, 3.5.6 shall be considered integrating part of the supply.

1.4 Component level of criticality

The level of criticality for the component , as per DPG/007, is LC1.

2. APPLICABLE DOCUMENTS

- MBTA N.8 Low Floor Cars Technical Provision (MBTA TS)
- Breda Document Q.A. SQU 143
- Breda Document SQU 279
- Breda Document R12/V.02.R01

3. REQUIREMENTS

3.1 Geometrical Characteristics

The axle shall be in accordance with the BREDA drawing J36/2.54.100. It is composed by two end parts (spindles, file J36/2.54.101) connected by means of two central crossbeams (file J36/2.54.102).

3.2 Spindle

3.2.1 Material

Spindle shall be a forged element made of 25 Cr Mo 4 steel as per UNI EN 10083/1, "bonificato" (quenched and tempered) to obtain the following mechanical characteristics:

Ultimate Tensile Strength $R = 590 - 790\ N/mm^2$

Yielding Point (as Proportionality Limit at 0.2%) $Rp = 440\ N/mm^2$ min

An impact strength KV of minimum 27 J at -30 °C shall be developed.

The chemical composition shall be as per UNI EN 10083/1 except for the content of the following elements:

$$P - S \leq 0.010$$

$$H \leq 2\ ppm$$

The steel shall be killed and have a fine grain.

The spindle shall be subjected to heat treatment of stress relieving after forging.

The parameters to use in the thermal cycle of stress relief are the following:

- Initial temperature: not greater than (200) °C.
- Heating up to the temperature Tc that will be a minimum of 30°C below of the tempering temperature, with thermal rise gradient between 60 °C/h and 150 °C/h.
- Permanence at the temperature Tc for 3 hour minimum.
- Cooling down to the temperature not greater than (180 °C), with thermal descent gradient not greater than (80 °C/h).
- Cooling continuation in quiet air.

A suitable system shall provide a continuos control and recording of temperature value vs. time.

3.2.2 Analyses, Tests and Inspection

The spindle supplier shall execute the following analyses:

- Chemical ladle analysis of each heat. The chemical composition shall conform to the requirements contained in Section 3.2.1.

- Tension test for each lot of forging. Test specimen shall be taken from spindle after final heat treatment (stress relief). Mechanical characteristics shall conform to the requirements contained in Section 3.2.1.

- Impact strength test KV for each lot of forging. Test specimen shall be taken from spindle after final heat treatment (stress relief). Impact strength shall conform to the requirements contained in Section 3.2.1.

- Ultrasonic test on 100% of pieces as per UNI 8572 parts 1,2 and 3, with the following conditions:

■ Spindle Stem:

Longitudinal Scanning by using flat bottom holes of 6 mm diameter on reference block. Spindle shall be rejected if the amplitude of any discontinuity indication exceeds the indication levels obtained from the flat bottom holes. Any discontinuity indication exceeding 10% of the indication level obtained from flat bottom holes shall be noted.

Transversal Scanning by using flat bottom holes of 3 mm diameter on reference block. Spindle shall be rejected if the amplitude of any discontinuity indication exceeds 50% of DAC curve obtained from the flat bottom holes. The level of acceptability is raised to 75% of DAC curve in the central zone of the spindle stem (within diameter ≤ 25% of end diameter).

■ Spindle head:

Scanning by using flat bottom holes of 3 mm diameter on reference block. Spindle shall be rejected if the amplitude of any discontinuity indication exceeds 50% of DAC curve obtained from the flat bottom holes.

- Dye penetrant test as per UNI 8374 or magnaflux test as per UNI 8390 on 100% of pieces , on the raw parts or on the machined ones but that do not foresee a further machining. No superficial defects are acceptable.

3.2.3 Marking

The spindle shall be serialized and marked as per drawing J36/2.54.100.

3.2.4 Documentation

Independently from the requirements of the document SQU 143, the spindle supplier shall provide the certification relative to analyses, tests and inspections contained in section 3.2.2, and certification relative to tempering and stress relief heat treatment.

3.3 Crossbeam

3.3.1 Material

Crossbeam shall be a section bar element of double T shape.

Crossbeam shall be made of Fe 510 D1 UNI EN 10025 normalized, with a minimum impact strength KV of 27 J at -30 °C.

Crossbeam for axles relative to prototype and pilot vehicles could be obtained by machining of forged bar of Fe 510 D1.

3.3.2 Inspection

Inspections as per UNI EN 10025 ("controllo specifico" - "specific control") shall be executed.

3.3.3 Documentation

Independently from the requirements of the document SQU 143, the crossbeam supplier shall provide the certification relative to analyses, tests and inspections contained in section 3.3.2.

3.4 Heterogeneous Welding

3.4.1 Welding manufacturing

Connection between spindle and crossbeam is obtained by means of a heterogeneous welding (joints 20S and 21S). Acceptable defects are those relative to butt joints or fillet joints with edges preparation of class B1 as per SQU 279.

The welding manufacturer shall establish the geometric details of edge preparations, shall execute the edges machining both on the spindle and on the crossbeam and shall provide the relative PQRs and WPSs. Welding qualification shall be obtained on the base of results coming from welding specimens, and shall be made by BCF/RQF, following also the requirements contained in section 3.4.3.

The axle shall be subjected to heat treatment of stress relieving after welding.

The parameters to use in the thermal cycle of stress relief are the following:

• Initial temperature: not greater than (200) °C.

• Heating up to the temperature Tc that will be a minimum of 30°C below of the tempering temperature of the spindle, with thermal rise gradient between 60 °C/h and 150 °C/h.

• Permanence at the temperature Tc for 3 hour minimum.

• Cooling down to the temperature not greater than (180 °C), with thermal descent gradient not greater than (100 °C/h).

• Cooling continuation in quiet air.

A suitable system shall provide a continuos control and recording of temperature value vs. time.

3.4.2 Welding specimens

Welding specimens reproducing the geometry of joints 20S and 21S shall be built.

Independently from specific requirements of BCF/RQF, to qualify the welding process the following controls on the welding specimens, as minimum, shall be executed:

- Ultrasonic inspection to verify the joints 20S and 21S be conform to class B1.

- N. 3 Impact tests on the joint 20 S in the HAZ in the side of Fe 510 D1 to verify minimum impact strength for Charpy V-notch specimen be 21 J at -30°C.

- N. 3 Impact tests on the joint 20 S in the HAZ in the side of "25 Cr Mo 4 to verify minimum impact strength for Charpy V-notch specimen be 21 J at -30°C.

3.4.3 Inspection

The welding manufacturer shall provide the following inspections on the weldings 20S and 21S:

- Visual inspection on the 100% of cranked axles and on the 100% of weldings before of stress relief heat treatment.

- Inspection with dye penetrant or magnaflux on the welding to assure it be free of superficial defects.

- Ultrasonic test inspection on the 100% of cranked axles and on the 100% of weldings after stress relief heat treatment. Scanning shall be executed by using flat bottom holes of 1.5 mm diameter on reference block. Cranked axles shall be rejected if the amplitude of any discontinuity indication exceeds the indication levels obtained from the flat bottom holes.

3.4.4 Specimen for fatigue test

The welding manufacturer shall supply N.8 specimens for fatigue test as per drawing contained in Attachment 1. The specimens shall be built in conformity with the qualified WPS, and shall be subjected to stress relief heat treatment and ultrasonic test inspection.

Fatigue tests shall be executed by BCF/LAB to verify the minimum fatigue strength at 5 millions of cycles for pulsating bending be 120 N/mm^2.

3.4.5 Documentation

Independently from the requirements of the document SQU 143, the welding manufacturer shall provide the certification relative to analyses, tests and inspections contained in section 3.4.2, 3.4.3 and 3.4.4, and certification relative to stress relief heat treatment.

3.5 Cranked axle

3.5.1 Machining

On the complete cranked axle shall be executed the foreseen machining.

The supplier of machining shall provide a step by step procedure for the dimensional control of the finished axles that shall be submitted to BCF/LPC for approval.

3.5.2 Marking

Cranked axles shall be serialized and marked at one spindle end as per drawing J36/2.54.100.

3.5.3 Painting

Cranked axles shall be painted, on the surface free of machining, in conformity with Breda document R12/V.02.R01 for components "truck". Machining parts shall be protected with Tectyl.

3.5.4 Final Inspection

Final inspection shall foresee a dimensional control of the cranked axle and a verification of all the certifications relative to all the components utilized to built the axle subjected to final inspection (spindles, crossbeams and weldings).

3.5.5 Prototype axles

Two prototype axles shall be built and controlled step by step during the manufacturing.

These axles shall be sent Breda to utilize them during the truck fatigue test.

3.5.6 Documentation

Independently from the requirements of the document SQU 143, the final inspection certification shall contain all the documents as per section 3.5.4.

3.6 Quality Assurance

The requirements relative to Quality Assurance are contained into Breda document SQU 143.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

TECHNICAL SPECIFICATION

EE&QA - 962

Definitions and Abbreviations

ISSUED: **August 11, 2023**

REVISION: **1**

SUBWAY OPERATIONS DIRECTORATE
EQUIPMENT ENGINEERING AND QUALITY ASSURANCE

Table of Contents

1.0 DEFINITIONS

1.1 Wherever the following terms are used in this Specification, the intent and meaning shall be interpreted as follows:

1.1.1 Whenever in the Specification the words "acceptable", "accepted", "approval", "approved", "authorized", "condemned", "considered-necessary", "deemed necessary", "designated", "determined", "directed", "disapproved", "established", "given", "indicated", "insufficient", "ordered", "permitted", "rejected", "required", "reserved", "satisfactory", "unacceptable", "unsatisfactory", or words of like import are used, it shall be understood as if such words were followed by the words in writing, "by the Authority" or "to the Authority", unless otherwise specifically stated.

1.1.2 Wherever the word "indicated" is used, it shall be understood to mean "as described in the Specification" or "as required by the other Contract Documents."

1.1.3 Wherever the words "provided", "supplied", or "installed" are used in the Specifications in reference to work to be performed by the Contractor, it shall be understood to mean "furnished and delivered completed".

1.2 Acceptance: (As applied to a truck or other physical asset) The transfer of ownership of the vehicle or other physical asset from the Contractor to the MBTA.

1.3 Acceptance: (As applied to design information, technical documentation or similar intellectual property) Reviewed for conformity to Specification and accepted, in writing, by the Authority.

1.4 Accepted Equal: Whenever the words "accepted equal" or "equal" are used in connection with material or equipment, the proposed alternative shall be functionally compatible with and of equal or better quality than the item it is proposed to replace. The Authority's decision as to whether any material or equipment proposed is equal to that specified shall be binding on both the Authority and Contractor.

1.5 Approval: Review and acceptance in writing by the MBTA.

1.6 Approval Pending: The Contractor must not proceed with the work affected by the noted comments until the Contractor has responded to the comments, the comments have been reviewed, and the status of the submittal has been changed from “Approval Pending” to “Approved”.

1.7 Approved Equal: See Accepted Equal.

1.8 Approved: Given approval by the MBTA, the Contractor may proceed with the work addressed in the submittal. Any Approval by the Authority shall not relieve the

Contractor from the responsibility to comply with all requirements of this Specification in all aspects of work.

1.9 Authority: The Massachusetts Bay Transportation Authority.

1.10 Baseline Design: The design of the truck or any of its components, apparatus, systems, sub-systems, or materials which has received both design review approval and first article approval by the MBTA.

1.11 Burn-In: An operational test conducted by the Contractor after all other tests are successfully completed.

1.12 Calculations: Numerical computations performed to demonstrate compliance with the Specifications, technically substantiate a design or position or otherwise show due technical diligence.

1.13 Car: MBTA Green Line No. 8 Light Rail Vehicle.

1.14 Case-by-Case: Considering or dealing with each instance separately, taking into account its individual circumstances and features.

1.15 Comment: The MBTA’s written critiques of the Contractor's submittals to the MBTA.

1.16 Commonwealth Of Massachusetts: State of Massachusetts.

1.17 Conditional Acceptance: The acceptance of the End Product by the Authority at the designated delivery point after discrepancies listed on the Receiving Inspection Report have been sufficiently corrected, acceptance testing successfully completed, and the End Product certified for revenue service by the Authority. The End Product remains conditionally accepted until it is completely compliant with the Specification requirements, the warranty period is completed, and corrective action(s), if any, are implemented to the Authority's satisfaction. Conditional Acceptance shall mark the start of the Contractor’s warranty period.

1.18 Contract: The written agreement executed between the Authority, Party of the First Part, and the Contractor, and Party of the Second Part, setting forth the obligations of the Parties thereunder, the performance of the procurement as indicated in the Proposal Documents and all authorized changes to this Contract issued subsequent to the execution of the Contract.

1.19 Contract Documents: The Contract Documents include the following: Contract Provisions and Specifications; Addenda; Contractor's Proposal, including any technical information submitted thereunder; Performance Bond; Non-Collusion Affidavit; Buy America/U.S. Content Compliance Statement (as applicable); DBE Participation Certificate; Power of Attorney; Ineligible Contract Affidavit; other pertinent document(s)

as required - all of which constitute one instrument. Any Change Order that is subsequently executed shall make reference to and become part of the Contract.

1.20 Contractor: The Prime Contractor solely responsible to the Authority for the quality and proper functioning of the End Product and all components; the person or persons, firm, partnership, corporation, or combination thereof which has entered into this Contract with the Authority to supply the End Products.

1.21 Contractor's Drawings: Items such as general arrangement drawings, detail drawings, engineering specifications, purchasing documents, graphs, diagrams, and sketches which are prepared by the Contractor to detail and define its work.

1.22 Days: Unless otherwise designated, days as used in the Contract Documents will be understood to mean calendar days.

1.23 Day(s), Working: Those calendar days during which regular business is conducted, excluding Saturdays, Sundays, and all MBTA-observed Federal, State, and municipal holidays.

1.24 Defect: Patent or latent malfunction or failure in manufacture or design of any component or system that causes a vehicle to cease operating, causes it to operate in a degraded mode or causes it to operate contrary to the documented design.

1.25 Delivery: Receipt at the Authority of the End Product in a sound, whole, ready to run condition. The Contractor shall complete and deliver all equipment and materials defined in the Contract Documents, to the Authority-designated delivery point.

1.26 Delivery Point: The location on the Authority's property to which the end products are expected to be delivered. For purposes of this Contract, the delivery point will be the Riverside Car House.

1.27 Design/Fabricate: Shall mean design, analysis, fabrication, installation, and testing of a new component/assembly. Authority approval is required for all design documentation, analysis and test reports, and installation procedures.

1.28 Digital Copy: Files delivered on a Flash Drive or CD.

1.29 End Product: The Contract item(s) furnished by the Contractor in accordance with the Contract Documents. End Product(s) includes, but is not limited to, trucks, bolsters,

drawings, specifications, instructions, books, education programs, spare parts, and services.

1.30 Equal: See Accepted Equal.

1.31 Failure: An improper condition which will require the vehicle to be withheld from or removed from scheduled service for corrective action.

1.32 Final Acceptance: Occurs on or after completion of the warranty period, once all corrective actions and retrofit, if any, have been completed, and the End Product is considered by the Authority to be fully compliant with the Specification.

1.33 Final Assembly: Installation and interconnections of all components required to meet the requirements of the End Products; the inspection and verification of all installation and interconnection work; and the testing in-plant of the stationary product to verify all functions.

1.34 First Article Acceptance: The examination and approval by the Authority of an initial part, assembly, subassembly, system, subsystem, apparatus, or material, manufactured or assembled by either the Contractor or Subcontractors. The First Article Approval establishes the baseline design and the minimum level of quality. Although the exercise of First Article Approval shall be at the Authority's option, the contractor shall assume that the Authority will subject all of the above to first article examination and approval.

1.35 First Article Inspection (FAI): An extraordinary inspection of a First Article which accomplishes two purposes. First, it permits the Authority to see, in three dimensions, what could be seen only on two dimensional drawings up to that point. If the First Article Inspection is of a component that the Contractor is purchasing, rather than making itself, the First Article Inspection discloses details that were not visible beforehand. The First Article Inspection is usually the first point at which maintainability of the component can be evaluated, since it is the first point at which relationships between elements can be appreciated. The Authority may approve the design that is revealed at the First Article Inspection or may require changes in order that the component can meet the requirements of the Contract. Second, it is used to establish the quality level of workmanship that will be maintained for the balance of the components. The level is established jointly by the Authority and the Contractor.

1.36 Fleet Defect: The failure of identical items, by location and function, covered by the warranty and occurring in the warranty period, in a proportion of the End Products delivered under this Contract.

1.37 Hidden Damage: Repairs or replacement components required that are not otherwise covered within the scope of the Technical Specification. The Contractor shall only

proceed with corrective action for hidden damage upon receipt of written approval from the Authority.

1.38 Independent Failure: A failure which is not the result of another failure, either directly or indirectly.

1.39 Information: A disposition given for submittals made to explain an "Approved Equal" concept, a general approach to the work, or other information-only submittal. The Contractor must not proceed with the work addressed in such submittals until the concept has been finalized, submitted, and "Approved."

1.40 Inspect: Shall mean cleaning, inspection, painting, and related processes, such as measurements and tests, as defined in this Specification.

1.41 Inspector: A person or firm designated by the MBTA as its quality assurance representative.

1.42 Interface: The points where two or more systems, subsystems or structures meet, transfer energy, or transfer information.

1.43 Manufacturer: The builder or producer of materials, components, devices, equipment, or apparatus for installation on the End Products.

1.44 Material (Supplies): Any substances used in the repair of the End Products(s) or furnished to the Authority as part of the Procurement.

1.45 Material Review Board (MRB): A Material Review Board is a group of appropriately qualified individuals gathered to review and dispose of material or workmanship found to be non-conforming to the requirements of the Specification or Contractor's requirements.

1.46 MBTA: The Massachusetts Bay Transportation Authority, created by Chapter 563, Section 18 of the Acts of 1964 of the Commonwealth of Massachusetts, the Party of the First Part to the Contract.

1.47 Nonconforming: The inspection or test result(s) fails to conform or comply with the Contract or Specification requirements.

1.48 Not Approved: The Contractor must not proceed with the work. The Contractor must revise and resubmit the submittal in its entirety. The revised submittal shall address, to the satisfaction of the Authority, all the comments provided in the Authority's writing of the "Not Approved" disposition.

1.49 Notice: A written announcement.

1.50 Original Equipment Manufacturer(s): The original manufacturer of the End Products, components, or assemblies.

1.51 Overhaul: Shall mean the restoration of a component to equal the performance, service life, and appearance of that new component through inspection, testing, replacement of

worn and damaged parts, adjustment, cleaning, refinishing, repair of any damage, and any other rehabilitation work required.

1.52 Pre-Shipment Inspection: Source Inspection of product, parts, components, subsystems, or systems conducted immediately prior to releasing items for shipment to Contractor or other destination.

1.53 Procurement (Work): The furnishing of all equipment, items, materials, parts, systems, data, design, services, incidentals, labor, management, and performance of the requirements defined in the Contract Documents, including changes thereto, in order to produce and deliver the specified End Product(s).

1.54 Program: The total effort undertaken by the Authority of which the End Products may constitute a whole or a part.

1.55 Proposal/Bid: The Offer in response to the Authority's Request for Proposal, including the Contract Documents with Specification, to be submitted in the prescribed manner, properly signed and certified using the forms provided by the Authority as required and all data to be supplied by the Offeror to be in conformance with said Documents.

1.56 Proposal/Bid Form: The approved form on which the Authority requires proposals to be prepared and submitted for the work, and which is part of the Proposal/Bid heretofore defined. When executed by the Offeror, the proposal/bid becomes the Contractor's written offer to perform the work and furnish and deliver the equipment/materials at the prices quoted.

1.57 Qualify: As used in these Specifications shall be the determination that an assembly, sub-assembly, or any part thereof is satisfactory for continued service under the Contractor's warranty, or that the time is suitable for repair or overhaul to restore it to warrantable service, or that the item must be replaced with a new (or warrantable rebuilt) part.

1.58 Ready-to-Run: The End Product is in a state to install in a revenue vehicle and function as intended by the OEM and Technical Specifications.

1.59 Receipt, Received: Acknowledgement that a shipment has reached its destination.

1.60 Rejectable: See Nonconforming.

1.61 Related Defect: Damage inflicted on any component or subsystem as a direct result of a defect.

1.62 Reliability: The probability of performing a specified function without failure and within design parameters, for the period of time specified, under actual operating conditions.

1.63 Repair: Shall mean fixing specific damage following procedures and acceptance criteria approved by the Authority and outlines by this Specification. Repaired components/assemblies shall be within tolerances for new equipment, unless otherwise

approved by the Authority. Items determined to be beyond repair shall be considered Hidden Damage and shall be replaced.

1.64 Replace: Shall mean installation of a new OEM component/assembly or a new component/assembly meeting the OEM requirements, as specified, on all trucks and bolsters.

1.65 Replace As Needed: Shall mean installation of a new OEM component/assembly or a new component/assembly meeting the OEM requirements, as specified, when the existing component/assembly is found to be nonconforming based on the specified inspections and/or tests.

1.66 Representative: Shall mean any duly authorized agent of the Authority or the Contractor.

1.67 Safe: The condition in which passengers, crew, or repairers are secure from threat or danger, harm, or loss arising from improper design, manufacture, assembly, malfunction, or failure of the End Product or any of its components or systems.

1.68 Section: Refers to the indicated Section of the Specification, in addition to all subsections thereof, unless the context indicates otherwise.

1.69 Service Proven or Proven: The historical success of that equipment operating under similar conditions on other transit vehicles and has achieved a MMBF (Mean Miles Between Failures) consistent with the Authority's requirements.

1.70 Service: As In Service Use, Service Braking, Revenue Service: The operation of the End Products under normal conditions.

1.71 Shipment: The physical process of transporting the End Product and associated components, or other required physical deliverable item, from the point of manufacture, repair, or assembly to the next manufacturing, repair, or assembly facility, or to MBTA property.

1.72 Shop Drawings: Drawings or sketches prepared by the Contractor for use in its facilities to fabricate, purchase, overhaul, or assemble the End Product or any components thereof.

1.73 Source Inspection: Inspection conducted at the source of the product (generally Subcontractor/Supplier). May include the FAI or may be performed as part of an investigation or audit.

1.74 Subcontractor: An individual, firm, partnership, corporation, or joint venture to whom the Contractor sublets any part, subsystem, component or hardware for the Contract.

1.75 Supplier/Vendor: The persons, firm, or corporations who furnish materials/services to the Contractor. Supplier furnished materials/services shall comply with all the contract requirements. Note: During the course of this contract the MBTA may interchangeably

use the word subcontractor, supplier, subsupplier or vendor as synonyms, all the aforementioned being under contract to the Contractor.

1.76 Technical Specifications, Specifications: Specifications pertaining generally to the method and manner of performing the work and/or the qualities and quantities of equipment and materials and End Product(s) to be furnished under the Contract. The technical specifications may include provisions adopted and issued by the Authority or may include other standards incorporated in the Contract Documents by reference.

1.77 Traction System: The system of wheels, motors, gearboxes, brakes, direct controls and appurtenances that propels or retards a car in response to control signals.

1.78 Tram: A condition of ideal truck geometry in which the axles are perfectly parallel and the wheels in perfect lateral alignment. The centers of the journal bearings represent the corners of a rectangle. Tram is checked by measuring the diagonal and longitudinal distances between reference points on the journal bearing housings and truck frame pedestals.

1.79 Vehicle: Same as "Car".

1.80 Vendor: See Supplier.

1.81 Work (Procurement): Where the context will allow, the term "work" means the production of goods and services furnished in accordance with the Contract.

2.0 ABBREVIATIONS

2.1 Wherever the following abbreviations are used in these Contract Documents or on the Plans, they are to be construed the same as the respective expressions represented:

2.1.1	AAR	Association of American Railroads
2.1.2	AGMA	American Gear Manufacturers Association
2.1.3	ANSI	American National Standards Institute
2.1.4	ASME	American Society of Mechanical Engineers
2.1.5	ASNT	American Society for Nondestructive Testing
2.1.6	ASQ	American Society for Quality
2.1.7	ASTM	American Society of Testing and Materials
2.1.8	AW0	Empty Car, Ready-to-Run Weight
2.1.9	AWG	American Wire Gauge
2.1.10	AWS	American Welding Society
2.1.11	CAD	Computer Aided Design
2.1.12	CAP	Corrective Action Plan
2.1.13	CDRL	Contract Deliverable
2.1.14	CFG	Component Modification
2.1.15	EE&QA	Equipment Engineering and Quality Assurance
2.1.16	°F	Degrees Fahrenheit
2.1.17	FAA	Federal Aviation Administration
2.1.18	FAI	First Article Inspection
2.1.19	FDR	Final Design Review
2.1.20	FTA	Federal Transit Administration
2.1.21	FCAW	Flux Core Arc Welding
2.1.22	GMAW	Gas Metal Arc Welding
2.1.23	HAZ	Heat Affected Zone
2.1.24	HPCU	Hydraulic Pressure Control Unit
2.1.25	Hz	Hertz

2.1.26	ID	Inner Diameter
2.1.27	IEC	International Electrotechnical Committee
2.1.28	IEEE	Institute of Electrical and Electronic Engineers
2.1.29	IPC	Illustrated Parts Catalog
2.1.30	ISO	International Standards Organization
2.1.31	LFC	Low Floor Car
2.1.32	LRE	Light Rail Engineering
2.1.33	LRV	Light Rail Vehicle
2.1.34	MBTA	Massachusetts Bay Transportation Authority
2.1.35	MMBF	Mean Miles Between Failures
2.1.36	MRB	Materials Review Board
2.1.37	MSRP	Manual of Standards and Recommended Practices
2.1.38	MT	Magnetic Particle Inspection
2.1.39	NACE	National Association of Corrosion Engineers
2.1.40	NCR	Nonconforming Materials Report
2.1.41	NDT	Non-Destructive Testing
2.1.42	NEMA	National Electrical Manufacturer's Association
2.1.43	NTP	Notice to Proceed
2.1.44	OD	Outer Diameter
2.1.45	OEM	Original Equipment Manufacturer
2.1.46	PDR	Preliminary Design Review
2.1.47	P/N	Part Number
2.1.48	PQAP	Project Quality Assurance Plan
2.1.49	PQR	[Weld] Procedure Qualification Record
2.1.50	PSI	Pounds per Square Inch
2.1.51	PT	Dye Penetrant Inspection
2.1.52	RMS	Root Mean Square
2.1.53	SMAW	Shielded Metal Arc Welding

2.1.54	SMOM	Scheduled Maintenance and Overhaul Manual
2.1.55	SSPC	Society for Protective Coatings
2.1.56	TIR	Total Indicated Runout
2.1.57	TS	Technical Specification
2.1.58	UT	Ultrasonic Inspection
2.1.59	V	Volts
2.1.60	Vdc	Volts Direct Current
2.1.61	VPI	Vacuum Pressure Impregnation
2.1.62	VT	Visual Inspection
2.1.63	WPS	Weld Procedure Specification
2.1.64	WQTR	Welder Qualification Test Record